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The Mississippi River

ITS HYDRAULICS, VALUE, AND CONTROL.

"The wisdom of Congress should be invoked to devise some plan by which the great river shall cease to be a terror to those who dwell upon its banks, and by which its shipping may safely carry the industrial products of twenty-five millions of people."—*Garfield.*

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THE MISSISSIPPI RIVER.

LETTER OF HON. JAMES B. EADS

To Hon. WILLIAM WINDOM, United States Senate, dated St. Louis, March 15, 1874.

DEAR SIR: The improvement of the mouth of the Mississippi, proposed by me, consists in an artificial extension of the natural banks of one of the passes, from the point where they commence to widen and disappear in the Gulf to the crest of the bar, about five miles distant.

This method is indicated as the only proper one by the following facts:

The Mississippi is simply a transporter of solid matter to the sea. This consists chiefly of sand and alluvion, which is held in suspension by the mechanical effect of the current. A small portion, consisting of larger aggregations, such as gravel, boulders, small lumps of clay, and drift wood, is rolled forward along the bottom. By far the greatest portion is, however, transported in suspension. The amount of this matter, and the size and weight of the particles which the stream is enabled to hold up and carry forward, depend wholly upon the rapidity of the stream, modified, however, by its depth. The banks and bottom being chiefly sand and alluvion, are easily disintegrated by the movement of the water, hence the amount of load lost by any slacking of the current at one place will be quickly recovered in the first place below where the current is again increased.

The popular theory advanced in many standard works on hydraulics, to wit, that the erosion of the banks and bottom of streams like the Mississippi is due to the *friction* or *impingement* of the current against them, has served to embarrass the solution of the very simple phenomena presented in the formation of the delta of the Mississippi, because it does not explain why it is that under certain conditions of the water it may develop, with a gentle current, an abrading power which, under other conditions, a great velocity can not exert at all. A certain velocity

gives to the stream the ability of holding in suspension a proportionate quantity of solid matter; and when it is thus charged it can sustain no more, and hence will carry off no more, and therefore can not then wear away its bottom or banks, no matter how directly the current may impinge against them.

In the upper portions of the delta (which, according to some writers, extends a few miles above Cairo) the width of the river is very irregular. When a rise occurs the current is increased in the narrow parts of the river, and the carrying capacity of the stream consequently becomes greater, and it at once takes up an additional load. When, however, as the stream flows on it enters a wide expanse, the current is slackened and the excess of load is dropped to the bottom, and thus shoals or bars are formed. From such expansion of channel way the volume of water, thus relieved of a portion of its load, passes into another one of the narrow parts of the channel, and here its current, by contraction, is again accelerated, and the increased load which it can carry is immediately scoured up from the bottom and sides of the channel. In the bends the centrifugal force of the water makes the current more rapid on the concave bank of the stream, and there it usually gets its additional load, and the caving in of the bend testifies to the rapacity of the water at that point of its course. Once loaded, however, it can carry no more, and hence it may sweep around half a score of other bends below with equal velocity without injury to them. If it encounter another expanse, however, it again loses part of its velocity, and with it part of its load, to be recovered again in the narrower parts of its channel below. It is evident, therefore, that if the channel were at all uniform in size the current would be more constant, and the alternate depositing and recovery of part of the burden of the stream would be prevented. This loading and unloading is synonymous with caving banks and sand-bars.

The lower part of the river, nearly all the way from Red River to the mouths of the passes, is remarkably uniform in width, and is, therefore, comparatively free from falling banks and shoals. This part of the river is transporting its load with great regularity, and without interruption, to the sea, whilst that above, owing to the alternating contractions and expansions in its channels, transports its burden with great irregularity, dropping a part here and taking up a part there, and thus by successive stages, from season to season, it is borne forward.

If the volume of water were constant it is plain that the river would soon have a current of great regularity, because the deposit dropped in a wide part of the river lessens the capacity of the channel there by shoaling it and re-establishes the proper velocity of current, and thus stops further deposit at that place, whilst at the contracted channel the scour soon enlarges the passage and consequently reduces the current, and thus further scour ceases at that point.

In a channel of uniform width, when the river falls, the stream occupies only the narrower parts of it, and if these be still too great to maintain sufficient current to transport the load the excess is deposited in the channel, which is thus further diminished until the current is thereby accelerated to the proper rapidity, after which it ceases to deposit any more. When the Bonnet Carre crevasse occurred the river

below it (one hundred and seven feet in depth) was shoaled up thirty-one feet, because the volume of water in the river, being lessened by the crevasse, was no longer sufficient to maintain the normal current in a channel large enough to carry the entire river; consequently the current below the crevasse slackened and the excess of load was dropped in the channel until the bottom was filled up thirty-one feet deep with the deposit. This reduction of channel was sufficient to re-establish the current and prevent further deposit.

We see, therefore, that the causes which control the speed of the stream and those which give to it the ability to hold its burden of solid matter in suspension are constantly acting in opposition to each other, and thus the equilibrium between them is restored as often as it is disturbed by alternations in volume or by irregularities in channel.

We not only learn from this how simple some of the most apparently mysterious phenomena of the river really are, but also how futile it would be to attempt either to enlarge or to diminish the normal size of its channel anywhere within its alluvial bed. As rapidly as the engineer strives to deepen it without proportionately contracting it, and thus enlarges it beyond the capacity which these natural forces give it, just so rapidly will the current be slackened by the enlargement, and the deposit be dropped there, and thus lessen it again. And as fast as he may contract it just so fast will the current be increased, and the consequent scour enlarge it again by deepening it. The *magnitude* of the channel is determined by forces which it is neither necessary nor profitable for the engineer to encounter. The *form* of the channel he can control and alter. If he widen it, these forces will inevitably shoal it; if he contract it, they will just as certainly deepen it.

Revy, in his recent valuable treatise on "Hydraulics of Great Rivers," declares that the current is doubled by doubling the depth, and trebled when it is three times as deep, the inclination of surface being the same. The cause of this is owing to the reduced amount of frictional surface of the bottom and sides of the channel, where the stream is narrow and deep; and it explains why the shore current of the river is less rapid than the central current; the latter having less friction in proportion to its volume, the gravity of water in that part acts with less resistance.

The phenomena presented by the protrusion of the passes of the river out into the Gulf are equally as simple as those of the river above. A glance at the map shows how remarkably uniform is the width of each of them from their commencement until they reach the neighborhood of the Gulf. In the passes and in the river for several hundred miles above the slower shore currents have dropped their excess of load until the shores have been built up and narrowed in to such a degree that all further deposits by them tend to increase the steepness of the banks; hence the additional deposit slides down towards the middle of the channel bed as fast as it is dropped. The onward motion of the stream tends to continually draw in its waters from the shore (which is evidenced by the drift-wood flowing always in the middle of the channel of the stream); hence the water, after depositing part of its load near the shore, is again made capable of carrying it by the increase of its ve-

locity, when it again gets near the middle of the stream, and thus the central mass of water is continually made capable of taking up from the bottom the excess of load dropped by the shore currents. At the mouth of the pass this is not the case, for the angle of rest of the deposit or the natural slope is not yet attained there. At the Southwest Pass, for instance, after flowing for several miles through a deep channel with narrow and parallel banks, the stream widens out from about twelve hundred feet and a depth of sixty feet to ten thousand feet and a depth on the center of the bar of about fifteen feet. Here the shore currents are continually dropping the surplus load which their diminished velocity is unable to hold up, and thus the shores of the Pass are being constantly built up and narrowed in and brought to the surface of the water, where, with reed grass, marine plants, etc., they are gradually converted into dry land.

The strong central current, however, is maintained intact by the reduced depth over which the stream passes as it expands, like a fish's tail, out to the bar. The velocity of the stream being maintained by shoaling in depth as it expands in width, it is able to transport its entire load out beyond the bar excepting only that which it has dropped on the submerged and incipient shores of the Pass. Although the current is strong out across the bar, it is soon checked because of its immense width and shallow depth, by which great friction in proportion to volume is induced. Hence the load is deposited just outside the bar, and its constant outward growth is thus assured, while the growth of the shores of the Pass follow in due order.

The fact that a given current will keep in suspension a corresponding quantity of solid matter; that at a less velocity a portion of it will be deposited and taken up again at a greater, is fully recognized in experimental science, and has been extensively made use of for analysis of soils. An eminent investigator of this subject, Prof. E. W. Hilgard, of the University of Michigan, has classified silts according to the different velocities at which they deposit. This independent line of research fully confirms the view herein advanced in explanation of the phenomena presented throughout the alluvial bed of the Mississippi.

Humphreys and Abbot's Report on the Physics and Hydraulics of the Mississippi River.

REVIEWED BY JAMES B. EADS, C. E.

THE RELATION BETWEEN THE CURRENT AND THE SUSPENDED SEDIMENT.

In 1874, I stated in a pamphlet that the chief portion of the sediment discharged by the river into the Gulf is carried in suspension, and "that the amount of this matter, and the size and weight of the particles which the stream is enabled to hold up and carry forward, depend wholly upon the rapidity of the stream, modified, however, by its depth."

General Humphreys immediately afterwards said, this statement is "in direct conflict with the results of long continued measurements made upon the quantity of earthy matter held in suspension by the Mississippi River at Carrollton (near New Orleans), and at Columbus (twenty miles below the mouth of the Ohio), one of the chief objects of which was to determine this very question, whether any relation existed between the velocity and quantity of earthy matter held in suspension. These results prove that the greatest velocity does not correspond to the greatest quantity of earthy matter held in suspension; on the contrary, at the time of the greatest velocity of current at Carrollton, the river held in suspension but little more sediment per cubic foot than when the velocity was least."

The results when correctly interpreted prove precisely the contrary of the idea here conveyed by General Humphreys. He says that my statement is in direct conflict with them, and then proceeds in effect to tell us that there is no relation between the velocity of the current and the sediment carried in *cubic foot of water*, which is a very different thing, as the reader will soon see.

General Humphreys evidently means to convey the idea that the most rapid current carries but little more sediment than the least, when in fact by his own tables it carried more than twenty times as much as the least current at Carrollton and more than forty times as much at Columbus.

They use the terms "a cubic foot of water" and "the current" as expressions having one and the same meaning, whereas the current per second represents the force due not to *one* only, but to an immense number of cubic feet of water passing, in each second of time, by the place where the current is measured; and it is the total sediment suspended in this immense number of cubic feet that should be compared with the rate of the current per second.

One of the chief objects, we are told, was to determine "whether any relation existed between the velocity and the quantity of earthy matter held in suspension." In what? *In a cubic foot* of water, or in the whole river? Certainly in the latter, for the quantity in a cubic foot is of no practical value except as a means to determine its relation to the whole quantity.

They pushed their investigations, however, only to the extent of trying to find the relation between the current per second and the sediment in a cubic foot. Failing to discover this, for they proceeded no farther, and supposing that they had solved a problem in which they had neglected two essential elements, they announced their astonishing discovery that no relation whatever exists between the rate of current and the quantity of sediment suspended by it; or, in plainer English, between *cause* and *effect*.

This question could only be solved by bringing the elements of *space* and *time* into the computation for the sediment, just as they are brought into the current measurement—that is, by comparing the mean velocity *per second* with the total weight of sediment suspended per second. They, however, compared the mean velocity in every instance with the mean sediment contained in but a single unit of the river's volume, and they not only published the results of this meaningless comparison as *a proof* that there is no relation between the rate of current and the quantity of sediment, but they have founded unsound theories upon this error and have officially advised a dangerous system of river treatment based upon it.

I will now show *why* they should have compared the current per second with the total quantity of sediment passing by their point of observation in the same unit of time. To make this easily understood by the general public compels me to state much that will be commonplace to the scientific reader.

Motion can not occur in matter without an expenditure of force. The transportation of sedimentary matter in water can, therefore, only result from an expenditure of force, and only by supplying the requisite amount of force, as it becomes exhausted, can these matters be lifted up and kept from falling back to the river bottom. Being heavier than water, it is just as impossible to uphold them in it without force as it is to raise chaff in the air or sand and dust in a whirlwind without it. The current caused by the river flowing from a higher to a lower level supplies this force.

The investigation of all questions relating to the expenditure of force belongs to that branch of science called *dynamics*, and in all such problems, whether they relate to a treadmill or a steam engine; to the tiniest ripple or the grandest river; to a grain of sand as it moves onward to the sea or to the most majestic planet that pursues its pathway in the heavens, each and all involve the consideration of four distinct elements in their solution; and unless each one of these be duly considered no assumed solution of the question can be worth the paper on which it is made, except perhaps to "point a moral."

These elements are, first, *force;* second, *matter;* third, *space,* and, fourth, *time.* Gravity and pressure are examples of the first element,

and one of these (gravity) constitutes the first factor in our problem. The term volume, or mass, is used to indicate the quantity of the second element, while the term speed, or velocity, embraces the last two elements and indicates the space through which the force acts and the time involved in the action.

The amount of force expended can only be ascertained by knowing the weight or pressure exerted, the space through which it acts, and the time occupied in such action.

The relation of these four elements to each other may be illustrated by suspending two equal weights from the ends of a lever with equal arms, supported at its middle. While at rest they present simply a statical problem, in which force, matter, and space alone are involved. When in motion, however, the other element, time, necessarily enters into the problem. If motion be imparted to the weights, and one sinks towards the earth, the other will be raised through a space exactly equal to that through which the other falls. The velocity and mass of the descending weight gives the measure of the force expended. This force can only be determined by these three elements; first, the weight; second, the space through which it moves, and, third, the time required to move through the space. *The work done* consists in its raising the other *weight* through the same *space*, and in the same *time*. Therefore the force expended will be precisely the same that is required to raise the same weight, through the same space, in the same time. Hence it is an axiom that "The work done must bear an invariable quantitative relation to the amount of force expended."

If the point of support of the lever be moved from the center toward one weight until the latter will balance one only half as heavy, it will then be found that when the large weight descends in one unit of time through a certain space, the small weight will have been raised through twice that space in the same unit of time, and, therefore, the small one will have moved with twice the velocity. Hence, if we raise a weight through twice the space, in the same time, we must either double the force, or lift but one-half the weight. If we reverse the motion of the weights, and the smaller one descends, we illustrate the fact that by doubling the velocity half the force will lift twice the weight.

In the steam engine the pressure of the steam takes the place of the pressure of force exerted by gravity. To determine the power of the engine we must have, first, the pressure upon the piston; second, the space through which it moves; and, third, the time occupied in its movement. If the same pressure be maintained per square inch in each of two cylinders, and the velocity of the piston in one be twice as great as in the other, the more rapid one will develop as much power as the other with half the area of piston; just as half the weight on the doubled length of the lever arm can develop the same amount of force as the whole weight, because it will then move with twice the velocity.

The power of a waterfall is estimated by the same three elements. The weight of the water falling in one minute of time and the number of feet of space through which it falls in the time are multiplied together, and when divided by 33,000 foot pounds the quotient will repre-

sent the horse power of the waterfall or head of water; a horse being supposed to be able to raise 33,000 pounds one foot high in a minute of time.

It is unnecessary to point out by farther illustration the fact that these three elements, matter, space, and time, are inseparably related in any investigation to determine either the amount of force expended or of work done. I need only add that, no matter how intricate the machinery or secret the medium through which moving bodies transmit their forces, these three elements are as absolutely requisite to determine the amount of the force expended, or the work done, as the depth, width, and length of a rectangular box are to determine its capacity; and no matter how occult may be the relation between them, it is nevertheless as indissoluble, complete, and perfect as in this simple illustration.

The work performed is precisely equal to the force expended when operating any steam, water, or other motor, but the work *practically* considered is of two kinds, one of which may be called profitable or visible work, and the other unprofitable or invisible work, the latter being that part of the force which is expended in overcoming friction, back pressure, atmospheric resistance, radiation, &c.

The work done by the force which the Mississippi River expends we may, for the sake of illustration, also divide into two kinds, and call the first invisible or unprofitable work, among which we may class the overcoming of the friction of the bed of the stream, the friction among the particles of water, the resistance due to the irregularities and bends in the channel, the atmosphere, &c., leaving to be considered as the visible or profitable work the transportation of its immense burden of sediment. The problem we are considering, and which these gentlemen claim to have determined, is the relation which the current, or force expended by the river, bears to this great burden of earthy matter.

Let us suppose a railway train be used in transporting grain, and that we wish to determine the relation between the force (or coal) expended and the quantity of grain carried. We would carefully ascertain the total coal burned in some definite *time*, for instance, in one hour, and also the *total weight* of the grain carried in that hour, and likewise the *space* over which it was carried during that hour. We would then be able, by comparing the total coal with the total weight, to declare absolutely that so much coal or force expended was equal to the carrying of so much grain a certain distance in one hour, and the relation between the force expended and the work done would be so expressed.

In such investigation we would have: first, force (the coal); second, matter (the load of grain); third, space (the distance the load is carried); and fourth, time (the hour during which it was carried). By repeating the measurements under similar conditions, but with different quantities of time, space, and weight, this relation between force and work would appear constant and inseparable. An instructive comparison could only be made, either between the *totals* of the force and work, or between their respective *units*, and in either case *time* and *space* would be indispensable elements to be considered. But if the

total coal be only compared with the weight of a *single bushel* of the grain, and no note be taken of the *space* through which it was carried, nor of the total number of other bushels that were carried in the same *time*, the comparison would have no significance whatever.

* * * * * * * *

PRACTICABILITY OF DEEPENING THE RIVER AND LOWERING THE FLOODS.

The inclined plane formed by the *surface* of the river from the highlands down to the sea is called its slope. The intensity or *degree* of force exerted by the water in its passage depends upon the steepness of this slope. The *amount* of the force depends upon the mass or volume of the water and upon its velocity, the current being the result of the slope. The friction of the bed is the chief element which retards the current. The slope, the volume, and the friction are therefore the chief agents which determine the speed of the current. Others modify it somewhat, but they need not be considered here.

Now, if the reader will bear in mind that the water is charged with sediment according to its velocity, and that it flows through a bed of precisely the same kind of material it is carrying in suspension, and that if its velocity is increased it will take up a greater charge from its own bed, or if its current be slackened it will drop some of its charge in the channel and add to its bed, he will understand the important part which the *speed* of the current performs in the problem. Through the whole alluvial basin from Cairo to the sea the river must discharge as much sediment into the sea and over its banks as its tributaries pour into it. If it discharged less its channel would shoal up and its slope be steepened by the excess received from its tributaries.

If it carries more to the sea than is brought down into it from the tributaries the excess discharged must be taken out of its own channel, and this would deepen it and lower the slope. From this it is evident that there must be some means by which nature adjusts the speed of the current to suit the needs of the river. This is done by the relation which exists between the rate of current and the quantity of sediment carried in the water. If the velocity be too great the deepening of the bed follows. This lowers the slope and the current becomes less rapid. If the velocity, on the contrary, be too slow deposition in the channel continues to take place until the river bottom is raised and the slope steepened and a higher velocity is produced. These are the inexorable results of the relation between the current and its burden.

The river's slope, being the surface of the water, determines the height of the levees, and is therefore the vital question in the reclamation of the lands from overflow.

We see how the current alters the slope by the opposite processes of deposit and scour. We want to lower the slope to prevent overflow. When the current is too rapid deepening is the process nature sets up in the bottom of the river, and gradually the slope is reduced and a normal current succeeds. To reduce the slope we must temporarily increase the current. This can be done in two ways. Friction of the

bed is the element which retards the velocity. Where the river is excessively wide it will have more frictional resistance to overcome, and must there have a steeper slope. If we reduce its width at such place the first effect will be an elevation of surface above. This will create a rapid current through the narrowed part, and it will be deepened there, and the elevation of surface above will then subside; but the current will still continue to be rapid, because the narrow and deep form of channel created will have less friction than the former wide one, and the rapid current will therefore continue to deepen the bed until the original slope is so lowered that the current through the contracted channel is gradually reduced to the normal rate again. When this is done it will be found that the flood line or slope has been permanently lowered at that locality. This necessarily leaves the slope steeper immediately above the locality thus treated, and this induces a more rapid current and consequent deepening of the bed and lowering of slope still higher up. In this way the alternation of slope at one locality ultimately extends up to the head of the alluvial district. Of course this could not occur unless the most sensitive relation existed between the rate of current and the quantity of sediment suspended by it. Nor could it occur except where the bed of the river is formed of the same materials which it carries in suspension or of materials easily eroded or moved by the current.

Another way to lower the slope is to increase the volume of water in the channel, because friction does not increase in an equal ratio with the volume. The greater is the volume the lower is the slope, is a lesson taught by every part of the river and by every outlet and bayou in the alluvial basin. This is because the proportion of friction to volume becomes less as the volume is increased, and therefore if the volume is increased a lower slope will produce the normal rate of current or that rate which will carry its charge of sediment to the sea without either loss or gain. It is impossible to maintain *permanently* any greater rate of current than will suffice to do this in any sediment-bearing river in the world through its alluvial district. Bayou Atchafalaya at Red river carries a portion of the Mississippi to the sea with a fall of over six inches per mile, while the main river pursues a pathway more than three times as long, with a fall of less than two inches per mile. The greater friction in the smaller channel alone prevents a high rate of current through it. Its slope has been adjusted to maintain the rate required to discharge its waters and their earthy burden without injury to its own channel. If it were closed and its waters were compelled to flow in the main river the first result would be an elevation of the surface and a more rapid current; a deepening of the bed would follow this and a lowering of the slope would be the permanent result.

Lower levees would, of course, then be practicable. This teaches us that if we wish to lower the floods and deepen the channel we must close the outlets and crevasses and convey all of its waters through one channel to the sea.

* * * * * * * *

The following quotation is made from an article published by Major

(now General) J. G. Barnard, U. S. Engineers, in *Debow's Review* in 1850:

"I find this principle laid down in the work of Frisi, 'On Rivers and Torrents,' which was placed in my hands by W. S. Campbell. He quotes and confirms the rules established by another engineer, Guglielmini, which are that 'the greater the quantity of water a river carries *the less will be its fall*,' and 'the greater the force of the stream the less will be the slope of its bed.' And, again, 'the slope of the bottom in rivers will diminish in the same proportion in which the body of water is increased,' and *vice versa*. These rules have their explanation in the facts that the beds of rivers of the character above mentioned [like the lower Mississippi] are capable of resisting, unchanged, only a certain velocity of current, and, on the other hand, that the sedimentary matter contained in the river water requires a certain degree of velocity to keep it in suspension. From the counteracting tendencies of the above two causes a mean becomes established at which the current ceases to deposit its sediment and the bottom ceases to be abraded; in other words, the bottom becomes permanent. But if from any cause, such as throwing off a portion of the water through a waste-weir, the velocity of the current is diminished, it is no longer able to maintain its sediment in suspension, but will continue to deposit in its bed until, through the elevation of the bed, its velocity again becomes what it was before it was disturbed sufficient, to maintain its sediment in permanent suspension."

LEVEES.

By James B. Eads.

My views regarding the important agency of the levees in improving the *low-water* channel of the Mississippi River were not expressed in that report with a degree of emphasis which I then desired, and I am unwilling to commit myself now to any expression in the present report, which, in the slightest degree, tends to throw a doubt upon *the necessity* of, or to justify any further delay in the closing of these outlets. On the contrary, I deem it proper to urge with redoubled force the absolute necessity of their immediate closure.

From quotations hereinafter made from the previous report of the commission, it will be seen that it relies upon the increased volume of discharge for scouring more deeply the bed of the river and lowering its floods. The loss of its volume through outlets or crevasses is fully recognized in that report as the cause of the deposition of sedimentary

matters in the bed of the river, by which its flood surface is raised from year to year.

Observations made by the commission plainly show that the effect of the present gaps in the levees has been to raise the flood-line of the river many inches above any heights previously attained within the 700 miles in which they exist most numerously, between Natchez and the mouth of the Ohio River. Within this distance there have occurred during the last eighteen years innumerable crevasses, aggregating, in 1875, a length of about 100 miles, and throughout this part of the river the deposits have raised its bed so much as to greatly injure navigation, and to cause smaller floods to rise to heights never before attained.

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This basin extends from Commerce, Missouri (a few miles above the mouth of the Ohio) to the Gulf of Mexico, and has an average width of about sixty miles. Its length is about 600 miles in a direct line, and it contains about 34,000 square miles, or an area equal to that of the State of Indiana. At the upper end of the basin a spur of the Ozark Mountains has been cut through by the river at the town of Commerce, and through this, over a rocky bottom, six or eight miles in length, the Mississippi now flows. Forty miles above Cairo, on the Ohio River, the same spur has been cut through by that tributary. Throughout this entire basin, bounded by highlands on each side, we have every reason to believe that an estuary of the Gulf of Mexico once existed similar to the Gulf of St. Lawrence; or to the Rio de la Plata, which is now being filled and built up by the immense mass of deposits annually poured into it by the Parana and Paraguay Rivers. The floods of the Mississippi River, being highly charged with sedimentary matter, have filled this ancient and extensive estuary with alluvial deposits to the height of about three hundred feet above the sea at the upper end of the basin. The surface of the land thus made by the river has a comparatively regular descent from the upper end of the basin to the Gulf, being at Gaines' Landing, midway to the Gulf, about one hunhundred and forty feet above the sea. Through these deposits the river winds its tortuous course in a channel about one thousand one hundred and fifty miles long.

Experience and observation prove most conclusively that the quantity of solid matter which the water of the river is able to hold in suspension is strictly regulated by the velocity of the current. Therefore, during the natural process of this land formation, whenever the flood waters escaped over the banks of the channel, the loss of current in the water thus escaping caused the sandy or heavier portions of the solid matter held in suspension in it, to settle almost immediately on the submerged banks; while the argillaceous and lighter portions, which take longer to settle, were carried back by the feebler current to the swamps or lower lands, on which they were deposited over a much more extensive area. These lighter matters now constitute the blue and other colored clay strata which are found in all parts and at all depths of the basin. The river banks were thus kept constantly higher than the lands more distant from the stream. Before any levees were built on

them they were usually from ten to fifteen feet higher than the lands one or two thousand yards distant from the river.

The size of the flowing volume of any river constitutes, as will be seen hereafter, a very important element in determining the velocity of its current, and as the loss of volume over the natural banks has the effect of producing a more sluggish current in the main channel, a deposition of sediment resulted wherever this loss occurred.

In this manner the bed of the stream, during each successive flood, was built up higher and higher, while the water escaping over the banks built them up also. Thus the river and its banks were both gradually elevated above the neighboring lands until some important breach occurred in one or the other bank, and caused the river to seek a new channel through or over the lower lands. Illustrations of this process are frequently occurring at this time in the lower part of the basin. Sixty miles above the mouth of the river its flood surface is now seven or eight feet higher than the mean level of the Gulf, and through this sixty miles it flows to the sea between narrow banks that have been elevated by repeated overflows above the sea-level. From time to time the river has broken through these narrow embankments and found a steeper and shorter route to the salt water. Through such new route its heavily-laden waters bear immense quantities of sediment, which is deposited in the Gulf at the mouth of the outlet, because the current can carry it no farther. About thirty-five miles above the mouth, one of these outlets, known as "The Jump," occurred about forty years ago. It has already formed over a hundred square miles of territory upon which rice plantations exist, and on which trees are growing larger than a man's body. From six thousand acres of this land, purchased from the State of Louisiana, were obtained nearly all of the willows used in the construction of the jetties. The gradual enlargement of this subdelta has so lengthened the outlet and flattened the surface-slope of its branching channels that the current from the river through them, even in flood-time, is now too sluggish to carry the heavy sedimentary matters of the main river by that route to the sea, and hence this outlet is gradually closing up. When it first occurred the water in it was 100 feet deep; now it is scarcely four or five.

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Levees stop this land-building process, because they restrain the floods within the defined channel of the river, and so long as they are intact it is impossible for the banks or the bed of the river to be built up to greater heights by the natural process just described. It is an error completely, and often disproved, but still repeatedly advanced by misinformed persons, that rivers confined between levees have a tendency to have their beds elevated, and, as a consequence, to need a corresponding elevation of the levees. The Po and the Rhine and other rivers in Europe effectually disprove such assertions. Their channels have been deepened and their floods lowered as a consequence of perfect levees, and this, it will be presently seen, is an inevitable result of the laws which control the phenomena of sedimentary streams, wherever they flow in channels made through their own deposits. These principles or laws I will now endeavor to explain.

The term "slope of the river" is used by engineers to indicate the inclination which the surface of the flood bears to the sea-level. When *"the slope"* is referred to without qualification, it means the *flood-line* at the various points along the river, and is synonymous with the term "the fall of the river per mile." It has no reference to the slope of *the bottom* of the river. One end of the slope is unalterably fixed by the Gulf of Mexico. Other points in its line may be lowered or elevated to a certain extent by natural or artificial causes.

The force which produces the current is the fall of the water from a higher to a lower level, and the slope is an indication of the amount of this force. Other conditions being the same, the steeper the slope the more rapid will be the current.

The chief element which retards the current is the friction between the water and the bed of the stream. This friction increases as the surface in contact with the water increases, and is, therefore, greatest where the width is greatest, and conversely it is least where the width of the channel is least. Hence it is evident that the velocity of the current may not only be increased by increasing the slope, but also by decreasing the friction. It must be remembered that nearly all of the sedimentary matter transported by the water is carried *in suspension*, and that the quantity carried is in proportion to its velocity. Only a small quantity of it is rolled along the bottom. Hence, if the current be checked when its waters are heavily charged with this sediment (as they always are in flood-time), *a deposition of a portion of their burden becomes inevitable.* No fact in connection with the river is more thoroughly established than that *the current in flood-time cannot be checked in the slightest degree without causing a deposition of some part of the sediment.* Screens of iron wire with meshes one foot square, placed across shoals in the Missouri River have sufficed to retard the current enough to cause deposits 16 feet deep to be formed during one flood, and in this simple manner new banks have been developed in excessively wide parts of that river to deepen its channel and lower its slope.

EXTRACTS FROM

"Principles and Practice of Embanking Lands from River Floods as Applied to 'Levees' of the Mississippi."

By William Hewson, C. E.

The overflow of a river discharges a large proportion of its earthy matter upon the land. The confinement of the river within levees confines this proportion of its earthy matter to the channel. The immense amount of the material so added to the work of the stream may be in-

ferred generally from the fact that in the case of the Nile it was distributed over Egypt by overflow, and has caused the elevation of *the whole surface of the country* since the Christian era at an average rate per hundred years of 4½ *inches*. The greatness of the aggregate mass of matter added to the original proportion in its volume by the construction of levees may be inferred generally by the immense additions resulting from levees to the growth of deltas. But the carrying power of a water-course, like all other mechanical agencies, has its limit; and when we see any cause loading it beyond its previously established energy, we may reasonably expect that a portion of its excessive work will of necessity be left undone. The motive power acting up to its limit in the removal of matter from its source to the sea may be readily supposed under its insufficiency for the removal of the extra matter accumulated within its levees to drop a portion of that matter into irregularities in its bed. The matter so dropped may be supposed to accumulate in layers, as every accession of material increases the weight of matter to be used over and above the energy of the stream. But these causes of deposit in the beds of rivers apply in the surcharging of matter in streams, whether leveed or unleveed, though from the retention of *all* the matter within the channel by levees, much more strikingly in the case of levees. The Nile illustrates the fact that unleveed rivers undergo a constant elevation of their beds; for while the matter deposited during the overflows of that stream, as already stated, has elevated the surface of Egypt 4½ inches per century, the matter deposited within the bed of the river has elevated the level of that bed at the same rate. The facts in this case are so well defined that it may be well to place them here on record. At Damietta, the Balize of the Nile, where the elevation of overflow in the river is imperceptible, the elevation in the level of the river-bed and river-bank is inappreciable. At Cairo, 120 miles from the mouth, where the flood-level is 25 feet above low-water mark, the elevation of the land and of the river-bed is, since the Christian era, 5 feet 10 inches. At Thebes, 500 miles from the mouth, where the flood-level is 36 feet above the low-water line, the land and river-bed have been elevated since the birth of our Saviour 7 feet; while at the first Cataract, 100 miles up-stream, the level of the bed and of the bank have been raised since the same period as much as 9 feet. Assuming the same width of channel in the Nile at Cairo, at Thebes, and at the first Cataract, and assuming further the same amount of detritus carried off, volume for volume, by the overflow at each of those three places, we may not be surprised to find that a 40-foot flood, giving an elevation of bed to the extent of 9 feet, a 36-foot flood an elevation of bed to the extent of 7 feet, and a 25-foot flood an elevation of bed to the extent of 5 feet 10 inches, the height of flood bears an almost uniform proportion to the height of the elevation of the bed. Where the height of flood is nothing the elevation of bed is also nothing—at Damietta. In 1800 years, it is thus seen, that for every foot high of the flood at Cairo, the Nile has elevated its bed 2.80 inches, at Thebes 2.34 inches, and at the first Cataract has elevated its bed for every foot of flood 2.70 inches. This furnishes for streams perfectly analagous in all particulars to the Nile

an approximate scale for estimating the rate at which they elevate their beds while undisturbed by levees in the distribution of their detrital matter over the adjacent countries. But while such is the rate of bed elevation in unleveed streams, we have seen, as reasoned to above, that the rate of bed elevation must necessarily be much more rapid in rivers confined by levees. But one special fact confirmatory of this general proposition is, however, within our reach. The Rhine, which is leveed from the sea almost to its source, has since the Christian era elevated its bed at the City of Mayance 13 feet 4 inches. The levee influence in this case has been in operation for but 300 years; and, therefore, assuming the rate of elevation in the river when it overflowed its banks the same as that of the average of the Nile, the bed elevation for the 1,500 years of overflow must have been 6 feet, and for the 300 years of levees be so much as 7 feet 4 inches, or six-fold as great. The flood-level of the river Po, it is true, is said to be higher than the roofs of the houses in the city of Ferrara, but this statement is so loose that it may mean very much or very little. If the houses referred to be but one story high, the flood-level described in the statement may not be higher above the streets than ten or twelve feet. In London to-day it would not be considered wonderful if we heard that the Thames, during high tides, stood as high as the eaves of some of the small houses in Blackwall, south of the Thames. And in New Orleans it would not be at all surprising to learn that during the late floods the water of the Mississippi stood higher than the roofs of some of the little squat cottages on the edge of the swamp sloping toward Lake Ponchertrain. Originally, marine swamps, as London, New Orleans, and Ferrara, had been, it is after all not so very remarkable that the levels of those swamps should be found now, as they doubtless have been from time immemorial, considerably depressed below flood-water. Seeing, then, that the record is so loose in the case of the Po, it may be assumed that while that record points to a great elevation in the river surface since the construction of its levees, such an elevation, from the manner in which it is stated, must not of necessity be held as by any means alarming. So much for the reasoning and the facts as to the elevation of river levels, whether the rivers be or be not confined by levees. This question of bed elevation and, therefore, of surface elevation has been made a great bugbear in reference to the embankments along the Mississippi; but when the few facts known in the case are subjected to examination, only such planters as take a very active interest in their great grandchildren will, while reclaiming the magnificent wastes of the Mississippi, trouble themselves by the reflection that after the reclamation of those lands they may revert in some future century back to swamp, on the ground that the works of reclamation tend to elevate the flood-level of the river, according to the experience of a city 300 miles up the Rhine, at the rate per year of less than one-third of in inch!

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In deltas, rivers always divide into branches. Consequent on this branching the loss of volume in each outlet results—by the great increase of friction, &c.—in a loss of momentum. This loss of mo-

mentum, lowering the aggregate carrying power of the stream, results in a proportional acceleration of deposit; and, therefore, going on from its starting point—the branching—under the effects of a constant retardation, reaches its limit on the pass-bar. This, then, is the point of greatest deposit, and therefore of least depth; whereas the branching point is the point of least deposit, and therefore of greatest depth. Thus we find the Rhone, the Po, the Nile, the Ganges, like the Mississippi, all shallow in their passes, and deep above the separation of those passes from the main channels. These facts and reasonings on delta bars point directly to the natural remedy for lowering the water line through a delta and removing its bars. The diffusion of the water flow being the cause of those evils, their remedy lies clearly in its concentration. The condensing of the whole volume of a stream in one channel will, by increasing its momentum, give a carrying power that will remove and transport far out to sea the silt that, with an inferior carrying power, sinks into the bed of half a dozen passes. The improvement of river beds, whether for the purposes of navigation or drainage, ought never to lose sight of the prime importance of *concentrating the flow*, in order by thus increasing the momentum—the "scouring" power—of that flow to remove the greatest possible amount of deposit from the bed, and thereby deepen the channel; to propel that deposit out into the distributing currents of the sea, and thereby retard or stop altogether the extension of the delta. This conclusion is confirmed by the experiments of Gennette, the observations of Guglielmini, and all the subsequent experience of the most respectable practitioners in hydraulic engineering.

The bars of the Mississippi mouths are subjects of great importance to commerce. The report of attempts to remove one or more of those bars by dredging is incredible. Such an effort were a repetition of the story of removing the soil of the Augean stable. The mechanical power engaged in piling up material across the passes of the Mississippi is that of the Mississippi itself; and it were the rankest of folly to attempt to undo the *constant* work of that power by the puny efforts of some 100-horse-power dredge. The Mississippi itself is the only power that can be brought to bear in the case to undo permanently the work of the Mississippi. The Clyde, a century ago, did not present a navigation-depth of over three feet as high as the City of Glasgow; but, though the bars and general bed were hard gravel, such has been the effect of concentrating its waters between regular lines of wharfs and jetties that it, to-day, bears to the Quays of Glasgow sea-going vessels of some 20 feet draught. Concentration, then, of its waters in one channel is the only means for removing permanently the Mississippi bars; and thereby preserving for New Orleans a commerce that otherwise must become every day more embarrassed as the delta-advance adds uncertainty, difficulty, and danger to its commuication with the sea.

But the commercial ground applies also to the other grounds of this course. The concentration of the waters of the Mississippi will assist drainage by keeping down the water-line. The greater the momentum at the mouth, the greater the power of the river in displacing sea-water,

and the greater the displacement of sea-water, the greater the outflow of river-water. Thus, then, does the concentrating of the stream tend to the depression of the up-stream water-level.

Physics and Hydraulics of the Mississippi River.

REVIEWED BY JAMES B. EADS, C. E.

The river throughout the 1,100 miles of its course below the Ozark spur, near Cape Girardeau, likewise presents successive phenomena in direct conflict with the theory of the report. As we descend the river through its alluvial basin, the surface-slope of its flood-line becomes less and less steep below each succeeding tributary, and its volume becomes concentrated in one uniform channel, with increased depth and diminished width. At Cairo this slope is about 6 inches to the mile; at Vicksburg, about 4 inches; at Red River, about 3 inches; while below New Orleans it is reduced to less than 1½ inches to the mile. Thus the main stream and each of its active passes and bayous teaches us, that in proportion as the volume of discharge is diminished, the flood-slope of each is permanently increased.

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The flow of a river is partially checked by the bends and irregularities of its channel, but the chief element retarding its velocity is the friction of the bed. Gravity is the force that overcomes this friction. A pipe four feet in diameter has but four times the circumference or frictional surface of one only a foot in diameter, but will contain sixteen times as much water. Hence the frictional surface, retarding the flow in the larger pipe, will be only one-fourth as great, in proportion to volume, as that in the smaller one. Therefore, to create the same velocity in each pipe, we must apply more force (gravity) to the water in the smaller one. This is done by giving it a steeper slope. Nature has done this in adjusting the slope of the main stream and that of each of its outlets to the sea, in proportion to its volume of discharge. These slopes all prove that each is obedient to this inexorable law.

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To raise a given weight of sediment through a given depth of water in a given time must involve the expenditure of twice the amount of force that would be necessary to raise that weight through half that depth in the same time; and as force, depth, and velocity do not increase in the same ratio, it is evident that the depth at any given local-

ity must modify the quantity of sediment which any given rate of current can lift from the bottom. Consequently, unless we correct the results of the velocity and sedimentary measurements of the Delta Survey at Columbus and Carrollton by the varying depths occurring when they were taken, these "exact measurements" actually prove nothing. Unfortunately, this correction can not be made now. The rise and fall of the river at Columbus is over 50 feet, and no account whatever is made of this fact in connection with these measurements. A record of the surface heights of the water at certain localities gives no accurate indication of the alterations in depth, because the bed in all alluvial streams at various localities deepens as the water rises and fills up or elevates itself as the water falls. This is notably the case between the piers of the St. Louis bridge.

It does not follow, however, nor did I ever assert that the normal quantity of sediment due to a given velocity is *always* present. These proportions must necessarily change with the inconstancy of the river volume and the inequalities in the depth, size, and form of its channel, and likewise from the fact that caving of the banks generally occurs with a reduced current, while the river is falling, because the supporting pressure of the flood-water against the saturated banks is then withdrawn. Observations immediately below where the banks are caving would doubtless show the water to be overcharged with sediment.

An experience of nearly forty years teaches me that the Mississippi River water throughout its alluvial basin is constantly varying the proportions of its suspended matter in accordance with the constant alterations of velocity in its current and its depth. At one locality and moment the water may be overloaded, and then deposition will immediately begin and continue until the normal quantity only remains. The water thus relieved of a part of its load, when again quickened as it flows onward by some contraction in the channel or other cause, at once attacks the bed of the river to recover the quantity due to such increased velocity.

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OUTLETS RAISE THE FLOOD-LINE.

We will now see what would follow the opening of more outlets, which the report declares correct in theory, but reluctantly abandons for want of proper territory on which to apply it.

The commission assume that a waste weir at Bonnet Carre crevasse, "discharging 250,000 cubic feeet per second in great floods," would render the country below secure with the present levees. If this were so, three or four such waste weirs would lessen still more the flood-line below them. Suppose the river were thus depleted until the remaining water that would find its way to the sea by the present channel would only equal the present volume of Southwest Pass. Nature has given to this Pass a slope of 2 2-17 inches per mile to enable it to discharge its quota of the flood-water of the river, and if the present great channel of the main river received only so much as is now discharged by the Southwest Pass, it would be impossible to maintain sufficient veloc-

ity of current in it to prevent a deposition in its bed. This Pass teaches us that a slope of 2 2-17 inches is requisite to prevent such depositions, and if the volume of the whole river be reduced to an equality with that of the Southwest Pass, it would inevitably fill up and assume the slope of the Southwest Pass to the proposed waste weirs at Bonnet Carre. This, instead of protecting the lands below Bonnet Carre, would raise the flood-line at New Orleans (40 miles below Bonnet Carre) about 5 feet 8 inches higher than ever—an effect exactly opposite to that assumed in the report.

The reader must not confound the effect that would be produced if the *entire* river in *one* channel went out at Bonnet Carre with what would result if its discharge were broken up and dissevered by *many* outlets, as the commission recommend. When the volume of the main stream is split up by islands, its dissevered portions must necessarily assume steeper slopes to carry forward their burdens of sediment. Each outlet forms an additional island. If such islands were indefinitely multiplied, it is evident that all the little channels forming them must fill up or assume steeper slopes.

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CAVING BANKS ONLY OCCUR FROM IRREGULARITIES IN THE RATE OF CURRENT.

By the "undercharged" theory of the Delta Survey Report, caving banks are attributed to the direct action of the current against them, by which strata of sand underlying those of clay, &c., are supposed to be washed out. This is not correct. If the water be charged with sediment to its *normal* supporting capacity, it can not take up more unless the rate of current be increased. Caving banks are caused wholly by the alternations in the velocity of the current. These alternations are inseparable from a curved channel, because the current in the bends is usually more rapid than on the points; but if the channel be nearly uniform in width, the caving caused by the curves will be very trifling. In proof of this, many abrupt bends exist in the lower part of the river, where the whole force of the current has set for years directly against them without any important caving of the bank. The bend of Fort St. Philip is a notable instance. Great differences in the width of the flood channel constitute the real cause of the destructive caving of the banks. These induce great irregularities in the slope of the flood-line and consequently great changes in current velocity, by which the scouring and depositing action are alternately brought into very active operation. The whole river below Red River proves this. Caving banks are much less frequent there than above, because the flood width of the river is far more uniform.

A correction of the *high-water channel* by reducing it to an approximate uniformity of width would give uniformity to its slope and current, almost entirely prevent the caving of its banks, and through its present shoals, which now constitute the resting-place for its snags, there would be a navigable depth *in low water* equal to that which now

exists in its bends. By such correction, coupled with a few judiciously located cut-offs, the flood slope can be safely and permanently lowered above each cut-off, and in this way the entire alluvial basin from Vicksburg to Cairo can be lifted, as it were, above all overflow, and levees in that part of the river rendered useless. *There can be no question of this fact*, and it is well for those most deeply interested to ponder it carefully before rejecting it, for the increased value given to the territory thus reclaimed can scarcely be estimated.

I would, however, earnestly advise the immediate closure of the gaps now existing in the levees. It is not necessary, I think, to raise them to a greater height, in any locality, than 12 inches above the floods of 1858 and 1874. Where extensive lines of new ones are now required, they should be located to conform to a plan for the correction of the entire river channel, by which the present levees would be ultimately rendered useless and the low-water channel of the river deepened to at least 20 feet from Cairo to New Orleans.

SIX ERRORS RECAPITULATED.

I believe I have conclusively shown that each of the following six statements is in conflict with natural laws or observed facts and is, therefore, erroneous:

First. That increased volume will permanently raise the flood-line.

Second. That outlets will permanently lower the flood-line.

Third. That cut-offs will permanently raise the flood-line below them.

Fourth. That the river water is always undercharged with sediment.

Fifth. That no relation exists between current velocity and quantity of sediment suspended.

Sixth. That crevasses do not cause deposits below them.

Letter from Gen. J. H. Rice, of Fort Scott, Kan.,

To Hon. CHARLES H. GROSVENOR, Representative from Ohio, and published in Congressional Record, Vol. XXI.. No. 108, April 26, 1890.

NEW ORLEANS AND NORTHWESTERN RAILWAY CO.,
NATCHEZ, MISS,, April 21, 1890.

Hon. CHARLES H. GROSVENOR, *Washington, D. C.:*

DEAR SIR: I am a citizen of Kansas with interests in this State and Louisiana, and in their behalf and in behalf of hundreds of millions of Northern capital invested in this country, and in behalf of the

suffering people of these States, I address you relative to the overflow of the Mississippi River.

Ten miles of my completed road and thirty-odd miles of road bed are under water. The Mississippi Valley Railroad is washed out in half a dozen places; travel and mails suspended. Twenty-odd miles of the Illinois Central Railroad are under water, and all travel and mails suspended. The track of the Vicksburg, Shreveport and Pacific Railroad is under water; also the Houston, Louisiana and Central Arkansas Railroad. Over 1,400 square miles of the most fertile land (alluvial) in the world is under water; thousands penned in their homes, stock drowned, and the suffering and loss is inconceivable.

This great flood of water does not come from Arkansas, Mississippi, and Louisiana, but from Michigan, Kansas, Illinois, Ohio—from twenty-seven States—and it is only sheer justice that the people of those States should aid these people in controlling the floods of this river. The alluvial lands of the Mississippi Valley are the richest lands in America, and not one-fifth of them are in cultivation on account of these overflows.

Hundreds of thousands of dollars are annually appropriated by Congress to improve navigation of streams—some in this vicinity that will not swim a duck two months in the year—under the idea that it is in the aid of commerce. Hundreds of thousands have been given by Congress for life-saving stations and preservation of property on our coasts, but when money to control the flood, of all these States that come down and overflow this country, causing great destruction of life and incalculable damage to property, is asked for, the answer comes back, "It's unconstitutional."

If this be so, it ought at least to be considered "unwise and unjust" to the people for Congress to waste their money on creeks and bayous that are of no public utility.

Could the assembled Congress stand on the banks of this river here, and see the courage and energy of these people—white as well as black—in the battle they are waging against the water, it would challenge their admiration and pity. The water stands from 6 to 18 feet above their farms and homes and all they hold dear, and for miles and miles only from 1 to 6 inches of the softened top of the levee is between them and destruction. And for three weeks, day and night, in mud and water, have these men struggled to hold their levees with as fierce a purpose as ever men fought in battle; their families and household goods in the rear, their safety depending upon the courage, strength, and labor of their husbands, sons, and brothers.

The critical time has come. If God in His wisdom does not withhold the rain and storm, miles of levee must go in the next forty-eight hours. Even then their fate is doubtful. Is there another nation upon the earth with one-half our resources that would not have cared for this river? It is disparaging to the Government and to the sense of justice of the American people that the people of these States should be abandoned as they have been in the past to the dire results of these floods.

As you doubtless know, the country contiguous to the river has

been divided by the Legislatures of these States into levee districts. The boards of these districts are corporations, and clothed with almost autocratic powers over taxation for levee purposes. In many of these districts a tax is made of from 5 to 15 cents an acre on land, 50 cents to $4 a bale on cotton, and from 5 to 15 mills on all taxable property. With this tax, from year to year, have most of the present levees been built. This is a very onerous tax, and yet it will not raise one-half the sum required.

The levee system, with revetment of banks and spur-dams to prevent caving (which should go hand in hand), is the only proper solution of this river problem. Wherever the water has been confined in a channel of 3,000 feet no sand-bar or deposit of silt can be found, and the channel would carry every drop of the flood but for the dams and obstructions of the river where it widens. There are no exceptions to this. Confine the water to a maximum channel of 3,500 feet by dikes, and revetment in bends and places when needed to stop caving, and one flood will scour out the channel until overflow will be a thing of the past. Outlets are a fraud. No outlet will lower the flood in the river permanently an inch, and below the place of outlet a bar of sand will at once form.

From 1800 to 1830 there were no levees above the mouth of Red River. When a flood came the water ran over at all low places and the whole alluvial country was under water. Then the current was slow, silt was deposited, and the bottom of the river filled up in places; and in 1813 the water was 48 feet 3 inches, in 1823 it was 48 feet 4 inches, in 1824 47 feet 7 inches, and in 1848 48 feet 4 inches—as high water as we have to-day. Outlets will destroy the navigation of the river, as can be seen at the mouth of Red River, where the water of the Mississippi runs up to the Atchafalaya; and the Raleigh crevasse which occurred four weeks ago, has been almost closed up by a deposit of silt below and in the mouth of the crevasse.

Congress alone can give relief. Every instinct of national pride, interest, and justice demands that this aid should be given, and given freely and abundantly, until these annually recurring floods are confined within the normal channel of the river.

I am, with considerations of respect,

Very truly yours,

JOHN H. RICE.

CONTROL OF RIVERS.

Extracts from remarks of the Hon. ROSWELL G. HORR, of Michigan, in the Congress of the United States, House of Representatives, January 15 and 16, 1884.

On the 15th Mr. Horr said:

I believe that the commission have adopted the only plan that will ever successfully improve and control that stream. I know that it will involve a large expenditure of money before we get through, but I believe the enterprise is so magnificent, so far-reaching in its results, of so much importance to the commerce and development of this country, that as a nation we ought to undertake it. In doing this I do not believe it will ever be done successfully without leveeing the banks as the commission has determined. Now, in building these levees for the purpose of confining its waters and thereby deepening its channel so as to improve the navigation of this river, what if it does happen to benefit the people living upon its shores? And admit, if you please, that they are a people who have differed with me seriously in the past, so seriously that it requires an immense effort to work myself up to a point where I can labor in their behalf, and I admit that it costs me a struggle [laughter], still, I say, even if it does benefit these people, in the name of God, shall we withhold an appropriation of this kind on that account?

I glory in the fact that it is likely to redeem from the overflowing waters of that stream land enough to make a State. That fact is an additional reason to me for favoring the project, and not an objection to the enterprise.

But the only question which we have before us to-day is whether we will permit this commission to go on with its plan and complete its work. If we intend to do so, then we should give them this money, because the last appropriation will be exhausted, and then the delay will cause more damage than the amount of this appropriation if this work is suspended until the regular river and harbor bill can be passed. Work on that river can not be prosecuted during the flood-time. They need to get ready for the high water of the spring time. Thus you see it is simply a question of whether we will rely on that commission and stand by them in their attempt to do this work or whether we intend to abandon them and the work altogether.

I am glad that my friend from Iowa [Mr. Henderson] has abandoned his effort to add another appropriation to this bill. This is not the first time we have passed a special appropriation for a needed work in advance of the regular bill. Members will remember that in the last Congress the engineers reported they were in need of $50,000 at Hell Gate for the protection and completion of work there, and that they needed the funds before we could pass the regular river and harbor bill, and a bill was passed in the Forty-seventh Congress meeting that emergency, which gave them that amount of money in advance. As a rule, I do not believe in putting these special appropriations through in advance of the regular bill, but this case, I think, is an exception, a just and proper exception, one which should be made in deference to the public good.

I do not believe in passing an appropriation for this stream simply because it is the Mississippi River. Any other work with the same surroundings should receive the same attention. I said the other day that some men seemed to think that the Mississippi River was the only waterway in the United States. I live upon a chain of lakes, the commerce of which in tonnage is several times the amount that passes down the Mississippi River. Do you know that the Detroit River floats over its waters during the summer season almost as much tonnage in two days as goes over the Mississippi River in as many weeks? Yes, it does. But of late the people who live on the banks of the Mississippi have not withheld from us a single dollar needed for the improvement of that great highway or for the harbors upon our Great Lakes. Nor do I believe you intend to do it. You are coming to understand the needs of all the great water-ways of this country. And our people are fast learning the importance of your great river that drains the greatest valley on this contiuent. The appropriation now asked for is for the benefit of that important work. As a nation we have undertaken that great experiment, and now we must either abandon it or furnish the money to carry on the work.

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On the 16th Mr. Horr said :

Mr. Chairman, I must say, upon reflection, and I do it after careful consideration, that I think the friends of the Mississippi River improvement ought to accept the amendment of the gentleman from New York. This amendment is directly in the line of what I understand to be the object we are attempting to reach. In the bill framed by the committee in the last session of the last Congress, which passed the House, but did not pass the Senate, we had substantially this same proposition. It was inserted, as I now recollect it, for this reason: Many members of that House, and I find not a few of the same way of thinking here to-day, looked upon this great undertaking as a simple experiment, and some of them as a very doubtful experiment.

Now, it was thought best to subject two of the most important reaches of the river to the test and apply the bulk of the appropriations to them until they should be completed, and then, if they proved

a success, there would be no further objection to the other large improvements and appropriations that would follow. If they proved a failure, we would ascertain that fact before we had expended any more money than was absolutely necessary. The two reaches selected in that bill are the same ones named in the amendment now under discussion, and I understand that the commission for the past year has devoted most of its time and attention to those reaches.

I speak as a friend of the Mississippi River; I speak as one who is not afraid of the bugbear of levees. I believe that stream will never be improved, as I said yesterday, until it is perfectly leveed on its banks. But people doubt that; there is a great deal of feeling in the country upon that question. It is the real cause of objection to this bill here to-day. Why not, then, accept this amendment? It will not interfere in the least with the great work being carried forward to completion.

I opposed the amendment of my friend from Indiana [Mr. Holman] because he sought to confine the work to simply one reach. I desire the commission to go on with their entire plan, and I thought his amendment tended to defeat the real object of this bill. I sometimes think my friend from Indiana makes and moves amendments simply as a congenital habit. I have sometimes thought that if he had had the power he would have moved to amend himself when he was created. [Laughter.] But knowing, as I now do, the gentleman's beauty and perfection of character, had it been in my power I would have opposed that amendment as strenuously as the one he offered to this bill. [Continued laughter.]

But this amendment of my friend from New York [Mr. Hiscock] is in the line, I think, of good business common-sense. It does not hamper this great work; it permits the commission to improve and take care of the Memphis harbor, the New Orleans harbor, the Vicksburg harbor, or any other work on the river which requires attention and care during the time that this $1,000,000 is being expended. Now, I say to my friends who favor this great enterprise, is not that proposition a fair one? Accept it, and we can pass this bill, in my judgment, in five minutes. I hope you understand my motive. I have been compelled to say this simply because I believe that it is in the interest of this great work, and, believing that, I must express my earnest convictions; and let me simply add that I do hope the gentlemen with whom I have worked so long and pleasantly in our endeavors to inaugurate this improvement will concede this much to many members here who really favor this appropriation, but think this limitation necessary. Of course I shall vote for the bill in either event, but shall feel pleased to have the amendment carry, and shall vote accordingly.

Extracts from remarks by Hon. ROSWELL G. HORR, of Michigan, in the Congress of the United States, House of Representatives, January 9, 1884.

I desire to remark that this is precisely the same contest that we had in the last two Congresses. In both of those Congresses, as my friend from Louisiana [Mr. King] states, the report of the Mississippi River Commission was sent to the Committee on Levees and Improvements of the Mississippi River. And for this reason the Committee on Commerce, at that time having charge of appropriations, withheld the question of the amount of the appropriation for the Mississippi River until the report on the levees and improvements had been received.

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Mr. Speaker, I think there is likely to be confusion about this matter, and yet it does not seem to me there is any question here which should lead to any difficulty. Now the former Congress supposed the consumption of time in looking up the Mississippi question was so great it interfered with the other duties of the Committee on Commerce and they could not have time to give it proper study; so they appointed a committee specially to take that subject up and digest it. The committee of course had to get an appropriation through the Committee on Commerce, just as other committees have to through the Appropriations Committee.

Now, I beg of my friend friend from St. Louis [Mr. O'Neill], whom I do not see in his seat, to listen for one moment, for, while I think he is right in his conclusion, yet he is wrong in the route he takes to get to it. He struggles with the difficulty that every man who lives on the banks of the Mississippi has struggled with ever since I have been a member here. He gets an idea that there is no other stream in the world except the Mississippi.

By special request from my friend from Arkansas, I leave him out. [Laughter.]

Now, when my friend from St. Louis talks thus early about "little creeks" and "little streams" in this country, he is talking on a subject in reference to which he will change his mind after he has investigated it. I am sensitive about these little streams. I have had some experience in reference to them, and, so far as their rights go, they are as sacred to me as the Father of Waters, which the gentleman from Missouri himself represents.

Do not let us get mixed up on this question. The Committee on Levees and Improvements of the Mississippi River ought to have the right to digest the plan and suggest the improvements which should be made to that river, and it is a big subject, and then the committee of my friend from Kentucky [Mr. Willis] should report the necessary appropriations precisely as the Committee on Commerce did last year.

Extract from a speech by Hon. ROSWELL G. HORR, of Michigan, in the Congress of the United States, House of Representatives, February 27, 1883.

Mr. HORR said:

I do not believe that the American Congress is going back on the idea of keeping these water-ways open. They are the greatest protection we have for cheap tranportation to the seaboard.

I am not going to detain the committee to-night by any lengthy remarks upon this bill. We have given the Mississippi from its mouth to its source $2,150,000, $1,500,000 of which is to be expended under the direction of the Mississippi River Commission below Cairo. I know there are gentlemen here who differ with me as to the success of that undertaking. I know there are men here who do not believe we can ever tame that great river if we try. I stand here to-night to say that I believe this nation ought to grapple with this problem and solve it if it can. I know there is a good deal which can be said for levees and against levees. But I wish to say to gentlemen here that we shall never know whether we can control and improve the river unless we try. I am neither a prophet nor the son of a prophet; and, while I know I speak in opposition to the opinions of a large number of members here, I desire to put it on record now that I do not believe that any system which you shall adopt in the great future for the improvement of the Mississippi River which leaves out the leveeing of its banks and the confining of its waters when high will ever be a success. I believe, while levees may not contribute to the improvement of low-water navigation, that the river can never be controlled and managed on any plan which does not provide for and prevent these disastrous overflows. However, in this bill we appropriate not one cent for levees. We have simply given the smallest amount which the commission think is necessary to improve the two lower reaches, about which we all agree. There is not a dollar in the bill for levees, but simply enough to go on with the experiment and finish those two reaches.

Extracts from remarks of the Hon. FRANK HISCOCK, of New York, in the Congress of the United States, House of Representatives, January 16, 1884.

Mr. Hiscock said:

Remarks have been made upon the floor here at least by one gentleman—and I do not care to be more particular than that—to the effect that New York is opposed to internal improvements; that New York is in favor of locking up the Treasury. Now, sir, New York is in

favor of internal improvements. New York votes millions of her own money for internal improvements, and New York is willing that money shall be taken from the Treasury for internal improvements; but she wants to know that this money is to be expended for internal improvements and is not to be expended for the benefit of private property. The proposition which is now tendered is to test the plan, to pick out the two places upon which the most money has been expended, to devote this money to the completion of the work at those places, and, if it proves a success, no New York member will stand in the way of liberal appropriations for the commerce and for the navigation of the Mississippi River.

But what we want, sir, is to have it demonstrated that this is not a great scheme for the benefit of the alluvial lands that are on either side of the Mississippi River. And I say to you, gentlemen on the other side, that when you oppose this amendment, when you leave it so there is a chance to have it said that this money may be scattered from one end of the Mississippi to the other to strengthen her weakened levees, you are affording reasons and grounds for our questioning the object of the bill and the appropriation. As has been well said by the gentleman from Michigan [Mr. Horr], test the work, test the plan, and, if the work and the plan prove a success, there will no longer be objection on this floor, either in this or in any future Congress, to give such money as may be needed for the improvement of the Mississippi River.

I say to you, on the other hand, if your object be the improvement of these alluvial lands, then defeat this amendment. It proves that you are unwilling to have the plan tested; that you are unwilling to have time enough elapse, if you please, to let the people fully understand whether this plan may be a success or not. It means that you propose to put through legislation and get money here, as I said at the outset, protection to lands being the main purpose and the improvement of navigation simply incidental to it.

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I wish to say, Mr. Chairman, that when I commenced working on this Committee on Commerce I was troubled over this Mississippi question. I sat here during the last Congress and listened to the debate on this great problem, and I am frank to say I did not succeed in mastering it, and I now enter upon an attempt to explain the provision of the bill in reference to the Mississippi, with a great deal of diffidence, because I am aware it is a question which can be properly handled only by experts, by men who have devoted their lives to that kind of study. In this attempt I claim no originality, and shall be more than pleased if I can use the exact expressions of those who explained the plan in our committee meetings.

Let me say in the beginning I believe the trouble with the Mississippi Valley—I mean the Valley of the Lower Mississippi—is this: It is not yet finished—I am speaking geologically—that country is not yet matured. The Mississippi River has not yet completed its channel. If you give Nature time, she will heal all those crevasses so as to dig out a channel and leave that entire country dry and tillable. But to

do this, it would take ages, and what we propose to begin by this bill and what the commission which has the matter in charge propose to do is to hurry Nature up in this work; to do for the river in a few years what Nature would certainly do if you would give her ample time.

All I shall say in reference to this valley and this great work comes from a careful study of the reports and from listening to the engineers as they describe the work they propose to do.

The first thing to be understood in examining the Mississippi question is the kind of a river the Mississippi is. It is a sediment-bearing stream, a silt-bearing stream, if you please. The same laws which apply to a stream which carries an immense amount of sand and mud in its water will not apply to the clear running stream that passes over a rocky bottom.

The engineers tell us there are three laws, and three only, necessary to be understood before you can get any proper conception of the plan of the improvement of the Mississippi River. The first of these is that there exists an intimate relation between the velocity of a stream and the amount of sediment it will carry. I hope my friend from Louisiana [Mr. Gibson] will correct me if I make any mistake as I go along, as he is more familiar with this subject than I am; but I think I have it clear in my mind, although it is a problem which needs longer study than I have been able to give to it to enable me to state with complete accuracy all the laws and conditions that relate to it.

I say the first law is this—that there is a very close and intimate relation existing between the velocity of a stream and the amount of sediment it will carry, so that the more you increase the velocity the more sediment it will carry along with it. Our own experience proves that; we know it in our little creeks and ditches on our farms. Take any stream and increase its velocity and it will always take up more sediment and dig out a deeper channel. That is the law I refer to. Now the converse would be true—that the moment you slacken the velocity of a stream it will give up its sediment and deposit it.

The next law is that the velocity of a stream depends upon the slope or upon the fall of its water—that is, if you increase the fall, you increase the velocity and thereby increase the sediment-bearing property.

The third law is that in opposition to this slope, to retard the progress of a stream, is the surface of the river-bed—the friction, as it is called. Now, understand that it is a simple law which can be easily demonstrated that the greater the friction the less the velocity. For instance, if you take a tube with a diameter of one foot and another which is four feet in diameter, the friction in the tube of four feet diameter will be four times greater than in the one-foot tube; but the four-foot tube will carry through it a volume of water sixteen times as large as the one-foot tube. Consequently, while the friction in the four-foot tube is four times greater than in the other, the discharge of water from the larger tube is sixteen times greater; so that in proportion to the discharge of water the friction is greatly lessened by increasing the size of the aperture or tube through which the water flows.

If this be true, and Captain Eads tells us that these three proposi-

tions embrace the entire philosophy of this great river, then our course in reference to its improvement would be based upon simple philosophical laws. The bed of the Mississippi River is to a certain extent the one-half of a circle or circular tube. The more, then, you can increase the slope, for instance, by raising the head of the water at Cairo, while the other end of the tube at the Gulf remains the same, the level of the ocean being always fixed, the greater will be the velocity of the water in the stream; and, consequently, the more water will be discharged. The more you can increase the quantity of water in the bed of the river, the less the friction will be to the amount of water; and let me show you why. I can illustrate it to a certain extent by showing you by this diagram a cross-section of the bed of the Mississippi. You will see that the friction of the river on its bed is indicated by the entire line commencing at the top of the water level on one side and following the bed of the river up to the opposite side at the top of the water. Now, when the river comes up so that you raise the water, say five feet, you have still the friction of the entire bed of the river as before. But you have all of the vast volume of water which is represented by five solid feet in depth clear across the stream, with the small additional friction of only five feet on each bank. It does not have any effect at all upon the rest of the river—that is to say, there is little additional friction on the bottom caused by the increased quantity of water. It is estimated that a rise of six feet in the Mississippi will double the amount of water that will flow through its channel. Consequently, when you raise a river by a flood, you not only add to the slope, by giving it a deeper pitch, but you lessen the friction in proportion to the amount of water discharged, and thus you increase the velocity by this double power. And when you increase the velocity, you increase the power of the river to cut its own channel and carry the sediment down the stream. I think that is a proposition which is perfectly plain as I have expressed it. This is a matter which has been the subject of experimental work upon the river.

The passes at the mouth of the river illustrate the principle. There were three passes at the mouth of the river. One of these passes which was improved was twelve miles in length. How was it improved? In what way was the work done? Why, Mr. Eads, the engineer, made Nature do it by fixing a few dams at certain points in the two outside passes and diverting the current of the river into the center of this channel he desired to deepen. He took two of the passes and threw small mattress dams across the bottom of them to check the current, and this caused a deposit beside these dams, filling up the river at that point so as to throw a larger volume of water into the channel of the unobstructed pass. He then placed mattresses or revetments to keep the water of the stream in the twelve-mile channel confined, and when a flood came the extra water was forced into this middle channel and the laws of nature did the work. The water was increased in quantity; this gave an increased velocity, and it picked up the sediment from the bottom and carried it with it to the Gulf. In this way the channel was deepened. A channel which up to that time had been utterly impassable, except for small vessels, now deepened by this scouring process

of nature, has a depth of 25½ feet through its entire length. And this was accomplished by the simple principle that when water is confined to a narrow channel and its amount increased, its friction is decreased and its velocity increased, and thus you enable it to take the sediment out of the way and deposit it at some point where the velocity of the current is checked.

Now comes the other question—why is it that opening a crevasse in the banks of a river shallows the channel of the river? Right here the two systems differ—the outlet system, which some people on this floor I have no doubt believe in, and the system of this commission. I am frank to say that at first this outlet system struck me favorably; but I honestly believe that if any man will carefully examine the report of the commission and the testimony of the engineers in this case, he will become thoroughly satisfied that the outlet system must necessarily be a failure. The moment you make a break in the Mississippi River or any other silt-bearing stream and allow the water to escape and spread over the country, at that very moment you check the current below. The moment you check the current below, you diminish the power of the water to carry off the sediment, you stop the flow of the sediment, and the channel begins at once to gradually fill up. This is as plain as any other great law of nature, and it is as necessary that there should be a swift current to keep the channel clear as that any other of the laws of nature shall have their fulfillment from natural causes. This result is inevitable; consequently every break or crevasse you make in the banks of such a river injures its channel—shallows it. But I shall come to that further on.

Extracts from a speech of Hon. JOHN B. HAWLEY, of Illinois, delivered in the House of Representatives, January 24, 1870.

Mr. Hawley said:

In this great valley, at no distant day, will be centered the commerce, wealth, and power of this nation. Its richness of soil, variety of productions and of climate, make it the most desirable abode for man upon the whole earth. Even in this wonderful age of progress its growth in population, wealth, and civilization is unsurpassed, nor has it been excelled in any age or country. Into this vast region during the present century has been poured the mighty tide of population from the Old World and from the Eastern States of the Union. And still this tide is unchecked in its onward flow. The States of the Northwest were the hope and succor of the nation in the day of its great and sore trial. When the hardy sons of the Eastern States immigrated to their new homes they carried with them the civilization and Christianity of their childhood. They carried with them, too, that love of

country which in their breasts ever lived second only in intensity to the love they bore their God.

Sir, while I love the whole Union and will yield to no man in my devotion to it, I trust I may be pardoned if upon this occasion I speak freely of the people of my own section of this vast country. I speak of them particularly because I desire to see justice done them. I remind you of their fidelity to all their obligations as citizens, and of their justice to the East and to other sections of the Union, with the hope that I may secure justice for them. Sir, the gallant sons of the Northwest stood fast by the Union in the day when traitorous hands were raised to destroy it. From the prairies and the forests they came, and, like an avalanche, they swept down the Mississippi, up the Tennessee and the Cumberland, and with Sherman they marched to the sea. Others did well; all deserve the gratitude of their country; but history will record that these inscribed their names among the highest on the scroll of their country's fame. But many who went out to the fight never returned. Around a hundred thousand hearthstones there are vacant chairs. More than a hundred thousand lie sleeping upon distant battle-fields. Their blood has crimsoned the waters of the Mississippi, the Cumberland, and the Tennessee. They sleep upon the battle-fields made immortal by their undying valor. The long-roll, the rattle of the musketry, the roar of the artillery, the shout of victory shall never "awake them to glory again." These the people of the Northwest gave to their country that the Union might live and that liberty and free government might be perpetuated.

When you of the East wanted your rivers and harbors improved for your commerce, your profit, and your defense they generously aided you and united with you in voting millions of the public moneys for that purpose. For years they have raised the great bulk of the agricultural products of the country, and have paid the greater part of their whole crop each year to transport it to market. This they have been forced to do, while the great Father of Waters flowed constantly by their very doors, and would, but for the obstructions in its channel, and which could have been removed at a comparatively trifling cost, have borne their rich crops to the seaboard at such rates as would have greatly added to their wealth and prosperity.

The adoption of these measures which I urge upon your attention will tend still further to bind together in kindly union the North and South, as it will facilitate intercourse and commerce between the two sections. It will assist in enriching and strengthening the valley of the Mississippi, until she shall stretch out her mighty arms to either sea, and, grasping in her embrace the East and West, shall bind them together in a bond of unity and love which they will never have the will nor power to break. If we would perpetuate this Union, we must adopt such measures as will facilitate commerce and intercourse between the different sections. Otherwise sectional interest will in the futnre be the rock upon which the republic will be driven, and God grant that upon that rock she may not be wrecked.

It is by intercourse and by an interchange of products that people come to know each other intimately. It is by such means that a unity

of interest is secured between sections of country widely separated and which would otherwise have nothing in common. Sir, a wise statesmanship will constantly have in view, as one of the most important objects to be accomplished in this country, the furnishing of the cheapest and best possible facilities for commerce between its various parts. How else shall we bind it together in one, as with bands of iron, this mighty empire, destined as it is to spread and widen until it shall encompass the land washed by the four oceans of North America?

Let us, however, come a little closer to the subject, that we may form some just estimate of the great loss the States of the Northwest have already sustained, owing to obstructions to navigation in the Mississippi River, and which might be removed, as shown by the report of the Government engineers, at a cost really trifling compared with the great advantages to be gained. From the report of that able and accomplished engineer officer of the Government, General J. H. Wilson, having in charge the survey and improvement of the Rock Island and Des Moines rapids in the Mississippi River, and which report was made in the year 1866, it appears that he estimates the five States of Illinois, Wisconsin, Missouri, Iowa, and Minnesota, all bordering upon the river, "annually furnish from one-third to one-half of all the produce grown in the United States." Among the leading productions which he mentions are wheat, corn, beef, and pork.

The Commissioner of Agriculture, in his report for the year 1868, estimates the whole corn crop of the United States for that year at 906,000,000 bushels. Of this amount he estimates that the States of Illinois, Missouri, Indiana, Ohio, Michigan, Wisconsin, Minnesota, and Iowa produced over 465,000,000 bushels, being more than half the entire corn crop of the whole country. He also estimates the wheat crop of the country for the same year to amount to 224,000,000 bushels, and that of this amount the eight States I have named produced over 141,000,000 bushels, or more than one-half of the whole crop. The secretary of the Iowa Agricultural Society, in his report, states that the amount of wheat shipped from that State by railroad during the year 1868 amounted to a fraction less than 9,000,000 bushels.

In speaking of the products of the five Upper Mississippi River States, which I have already mentioned, and of their magnitude in the year 1861 and the two following years, General Wilson says: "They not only contributed one-third in value to our entire exports, but gave employment upon the ocean to more than one-half of our entire American tonnage, which was equivalent to one-fourth of the tonnage of all our trans-oceanic commerce." I have referred thus briefly to the amount of some of the products raised and exported by the States of the Northwest for the purpose of impressing upon this House the great importance of providing large facilities for the transportation of such a vast tonnage.

It will be observed that the products of the States of the Northwest are such as are needed by the rest of the country and such as it must have, and that the sections of country at all dependent upon these States for breadstuffs are and must be greatly benefitted by their cheap production and transportation. The same able officer states that if the

obstructions to the navigation of the Mississippi River were removed a bushel of wheat could be transported by that route from the Upper Mississippi to New York fifteen cents cheaper than by rail, and that the losses by detention and accidents on the lower or Des Moines rapids alone amount to the sum of $500,000 per annum, and that to cover extra hazards by reason of these obstructions an additional insurance of thirty-five per cent. of the usual rates is demanded. It will be observed that the estimated loss of $500,000 per annum applies only to one obstruction and to the freight actually passing upon the river, taking no account of the vast amount diverted from this natural outlet because of such obstructions. If in 1868 Iowa exported by rail more than eight million bushels of wheat it was because of the hazard and delays in shipment by the Mississippi River occasioned by the obstructions in its channel. The fact that vast quantities of freight are shipped by the river, notwithstanding all the obstacles to be overcome in its navigation, is sufficient proof that if once freed from these it would do a great part of the carrying trade and at an immense saving to the producer. Not only would the saving be upon the crops exported, but the people would be benefitted by the cheapening of freights upon what they buy abroad.

Having spoken of the amount of wheat exported by rail from Iowa in the year 1868, I deem it proper to state that her whole crop for that year amounted to twenty million bushels. The same year Minnesota produced fourteen millions, Wisconsin twenty-two millions, and Illinois twenty-eight millions. During the same year Illinois produced corn to the amount of one hundred and thirty-four million bushels, Iowa sixty-five millions, Wisconsin twelve millions, and Minnesota eight millions. When we consider the amount exported by river and by rail it is safe to say that these four States exported more than forty million bushels of wheat in a single year and untold millions of bushels of corn. The annual commerce of the Mississippi Valley is estimated to reach the enormous sum of two billions of dollars; and General Wilson estimates that the productions of the five States bordering upon the Upper Mississippi amounted in value in the year 1866 to more than eight hundred and eighty million dollars.

The annual loss sustained by the States of the Upper Mississippi alone, in consequence of the obstructions of the river at the rapids, is estimated to reach the sum of $10,000,000.

Mr. Speaker, while I would not disparage the railroads or seek to take from them any merit or praise that may be justly due to them, or to the enterprise and energy of the men who have built and are now operating them, I simply state a well-known fact when I say that in this country they have become vast monopolies. While in many parts of the country there is a large supply of roads within convenient distance and such as might, with a healthy competition, afford cheap rates to the shippers, and at the same time a good profit to the railroads, the latter, by combinations and consolidations, have so banded together to oppress and rob the people by extortionate charges that in many places they have scarcely left a sufficient profit for the producer to justify himself in shipping his products to market. With the improvement of the great rivers this state of things must in a large degree pass away. With

the life currents flowing freely through these natural arteries, with the obstacles to their navigation removed, and with competition, as it ever must be, open and free thereon to all, then, and not till then, will the Mississippi Valley have free and untrammeled intercourse with the outer world. The Mississippi River is, by treaty, by law, and in fact, a great national public highway, forever free alike to the citizens and to the commerce of all the States. It can never be subjected to tolls or charges, and consequently all sums of money expended for its improvement must be in a good degree to the common advantage of all the citizens of the Union.

With the obstruction to its navigation removed, freights could be transported upon it at a very low rate, and would always by competition remain at a fair living profit to the carrier. This would necessarily be so, for the reason that competition, being open and free, would of itself secure such a result. Not so, however, with railroads. These are severally owned and operated by a single corporation and the owners are left free to charge such rates as they may see fit, regulating such charges only by one standard—the ability of the shipper to pay.

Sir, the great body of the people of the Northwest are a thousand miles from the sea. They have for the purpose of improving their condition and to secure cheap and rapid transit to the seaboard given liberally of their means to aid in the construction of railroads. Thousands of them have given so liberally as almost to reduce them to bankruptcy. They have done this with the fond hope that when the roads should be built the disadvantages of their interior location would be overcome; they have given with the expectation that when the railroads should be completed and in full and successful operation the great productiveness and wealth of their soil would enable them to compete successfully with their brethren on poorer lands though nearer to market.

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Sir, what is needed to fill up the States bordering upon this river and the States and Territories lying to the west of it with population and wealth? I answer, more than anything else, cheap transportation. In this result the East is largely interested. With cheap freights the consumers of the East would get cheaper provisions. In fact, everything they buy of us would be cheaper, and we of the West would be benefitted by cheap rates upon what we sell to them and upon what they sell to us.

Thus will the burdens of the producer be lightened, an object ever to be had in view by the true statesman and lover of his country. It is upon the producing classes that all the burdens of government ultimately rest, and he who can lighten the load or add to the wages of labor must ever be regarded as a public benefactor. The producers are the wealth and glory of the State. To guard, protect, and foster their industries should be our constant care. Upon their prosperity depends the success in great measure of all others. When they prosper the country prospers. If their labor fails to yield a rich reward the whole country suffers, and bankruptcy and ruin is the result. The States of the Mississippi Valley pay more than half of the taxes to sustain this Government. This they do out of the surplus remaining to them after submit-

ting to the extortionate charges imposed upon them by the railroad companies for the transportation of the products to the seaboard. It should be the pleasure of every honorable gentleman upon this floor, by his vote and by his influence, to do all in his power to aid in a work so national in its character, so wide-reaching in its results, calculated as it is to benefit and bless so many of our countrymen. I may truly say that I know of no expenditure that can be made by the Government involving so little outlay from which so great results will flow as from the improvements upon the Mississippi River and its tributaries.

Upon another occasion Mr. Hawley said:

My recollections and experiences are somewhat similar to those of the gentleman from Massachusetts [Mr. Robinson], but more limited. I remember very well that I advocated the appointment of the commission for the examination of the Mississippi River, and that I answered some objections to it, the chief objection being that we were embarking in a vast and expensive scheme, by saying that, as everybody knew, something, and something important, must be done there, and an indispensable preliminary was to obtain a mass of information from scientific men, that we might have the knowledge upon which to base deliberate action and mature plans that would take a long time and large sums of money to carry out.

I voted for the commission in the hope that we should get such information, and supposing that when we got it we should sit down deliberately and perhaps establish a commission, give it powers, and lay out a great work. Now, we have received—what? This little pamphlet [holding up the report of the commission]. This is all the report this commission has ever made, or at least that has been printed for us. It contains only twenty-two pages, part of which is formal. It is styled a "preliminary or partial report," and a part of the twenty-two pages is occupied by a report of the protesting minority. I supposed I should get from the commission information—of this description, for example; that we should have a distinct line drawn between two classes of improvements—improvements with two distinct motives. One class of improvement would aim at protection of lands for the general benefit of agriculture. The other motive for works would be the improvement of the channel of the river solely for the benefit of commerce.

Now, obviously the rights and duties of Congress with regard to these entirely different purposes are as distinct as the purposes themselves. Have we a right to enter upon a gigantic system of land improvement? That is a great question. If we have we must give to a well organized commission power to condemn and appropriate lands, to assess and collect benefits, and to pay damages. But if, on the other hand, it is our sole duty and intention to improve the navigation of the river, that is a very different and simple affair, requiring a different commission and much less labor, because we are accustomed to enterprises of that kind.

I find in this little, brief, imperfect, and practically useless report no lines whatever drawn between these two classes of work. They are,

perhaps, not purposely but actually so mingled, so confusedly referred to that one has difficulty in perceiving what are the purposes of the commission. The protesting minority declare:

"Levees are of very little value in improving the low-water navigation of the river. Of their necessity in protecting alluvial lands against destructive floods there can be no doubt."

Extract from a speech of Hon. THOMAS J. HENDERSON, of Illinois, in the Congress of the United States, House of Representatives, January 15, 1884.

Mr. Henderson said:

I am not disposed, Mr. Chairman, to occupy the time or the attention of this committee in discussing either the necessity or the importance of the work of improving the Mississippi River. The question, it seems to me, which the committee should now consider, is whether there is a necessity for making this appropriation at this time. I had supposed, sir, that the importance of improving the Mississippi River had been almost universally conceded by all sections of the country. In the discussions on the floor of this House heretofore, the great objection to the river and harbor bill has been always that it included smaller and insignificant streams and harbors which were not national in their character and therefore did not deserve the consideration of Congress. But the importance of improving the Mississippi River has not been seriously questioned. Whether we should improve the Mississippi River by one system or by another is a question which I do not propose to discuss at this time. We have been discussing it for eight years, ever since I have have had the honor of a seat in Congress, and I had supposed that Congress had settled down upon the plan of constituting a commission for the Mississippi River, to be composed of eminent engineers, men of experience and ability, who were qualified to investigate and consider the question of improving the Mississippi River, and who would adopt some plan for that purpose and report the same to Congress; and upon the report of that commission we have been acting and making our annual appropriations for a number of years.

I think in the Forty-sixth Congress, in the first session of that Congress, after a full discussion of this great question, we finally appropriated a million of dollars for the improvement of that portion of the Mississippi River below Cairo; and in the last Congress we made a much larger appropriation. So Congress, it would seem, is fully committed, Mr. Chairman, to this plan of improving the river. I care not whether you call it an experiment or not. It was entered upon as an experiment, it is true, and it may be, as the gentleman from Michigan (Mr. Horr) has just said, still an experiment; but we have the report

of this commission, informing us that this plan of improving the river is proving eminently successful and satisfactory to the commissioners so far as it has progressed, and that it is in the interest of the improvement of the navigation of the river. Where we had but four or five feet of water a few years ago we are now having ten or twelve feet, and that in the worst and most dangerous places in the river.

Now, the work is progressing satisfactorily. The commission tells us that, and the only question here is, whether we shall appropriate a million of dollars at this time, the necessity of which grows out of the failure to make any appropriation at the last session of Congress, and the fact that the money before appropriated is now expended within a very small amount, and soon there will come a time when floods will rise in the river, and great loss and damage be sustained to the work already in operation if this appropriation is not made. That is the question for us to consider, and I will say, Mr. Chairman, that it was upon this ground that I favored, as a member of the Committee on Rivers and Harbors, this immediate appropriation. I have seen enough of public improvements since I have been a member of this body to know that there is always great waste in the public expenditures, growing out of the insufficiency of appropriations for the purposes of carrying on public works. Sometimes we appropriate 20 per cent. only of the estimates; sometimes we appropriate 40 per cent. of what is asked for, and sometimes 50 per cent. of the amount deemed necessary for the work, and the result is that in improvements like that of the Mississippi River and other streams, the entire plant is liable to be swept away and the amounts expended lost and destroyed, unless a sufficient amount is given to carry on the work begun to completion and to protect it from freshets while it is progressing.

The Mississippi River is a great river. Everybody concedes that it requires a great amount of money to improve it, and everybody can see that we have a great amount of money already expended there, and which is liable to be lost or destroyed by not going on and completing the work at the earliest possible day. This is a rule with reference to the improvements of all rivers; and that makes it necessary, and more necessary in the case of the Mississippi Rivery than others, because the amount involved is so much larger than the amounts which we have appropriated for the improvement of smaller streams.

Extracts from a speech of Hon. J. HALE SYPHER, of Louisiana, in the Congress of the United States, House of Representatives, June 4, 1874.

Mr. Sypher said:

Mr. Speaker. The Mississippi River is the highway to the markets of the world for half the inhabitants of this Republic. Its tonnage is

destined to exceed the international tonnage of the civilized world. It drains an empire over a million square miles in area. The same percentage of land being under cultivation as in France would produce food sufficient to subsist half the human family. The improvement of this great commercial channel, from its source to the sea, is a national work, the performance of which is a high national duty. The people's representatives must be alive to the paramount benefits resulting therefrom to the whole country. No sectional interests are involved in this question. The people inhabiting the Mississippi Valley by their industry supply the necessaries of life and raw material to the East in exchange for their manufactured products.

Nothing is detracted from the power and importance of the great manufacturing and trading centers of the States on the Atlantic slope in claiming that the commercial as well as the political supremacy of this nation is centered in the Mississippi Valley.

France's greatest soldier and most sagacious statesman, when he relinquished his hold upon the Louisiana territory at the conclusion of the treaty, remarked prophetically:

"This accession of territory strengthens forever the power of the United States; and I have just given England a maritime rival that will sooner or later humble her pride."

Again that great ruler remarked that:

"The day may come when the cession of Louisiana to the United States shall render the Americans too powerful for the continent of Europe."

Under the wise policy of internal improvements adopted by this Government and by the intelligence and industry of our people, in less than three-quarters of a century are these prophesies realized, though jealously and reluctantly acknowledged by the nations of the earth.

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Put this great river under national control; build and maintain the levees to protect the homes and property of the people residing on its banks; perfect the channel improvement for safe and easy navigation of vessels of every class, and you will have furnished a permanent, reliable, and adequate outlet for the trade and commerce of the great West. You will have dealt a death-blow to monopolies, and extinguished the corn-fuel fires of the prairie farmer, and supplied the East with abundant cheap food. Industry will revive in all sections of our common country, production will increase and be more remunerative, and the vast commerce of the Mississippi Valley will float on every sea and bless the inhabitants of every land.

Extracts from a speech of Hon. J. HALE SYPHER, of Louisiana, in the Congress of the United States, House of Representatives, January 6, 1874.

MR. Sypher said:

Mr. Speaker, in the remarks I am about to offer upon the pending bill, I desire to impress upon the House and the country the magnitude and importance of this question of the Mississippi levees, and of the necessity for sure protection from inundation of the vast areas of fertile lands comprising the Mississippi Delta. Your select committee, to whom was referred this subject, in their able report have presented an array of facts which must dispel all doubts as to the power and duty of Congress in this matter. A great necessity and responsibility is upon you at this moment. While I speak the lives and property of the people inhabiting the Mississippi Valley are being destroyed by the turbulent waters of that overpowering and uncontrolled stream.

No power outside of the General Government is adequate to protect the wide expanse of fertile territory, and give confidence to capital and labor to occupy and cultivate it. Individuals, corporations, and States all have hitherto in vain attempted to confine the waters of the Mississippi within its banks. Millions of treasure have been expended in these fruitless efforts until the States are impoverished and the people are bankrupt. A crisis is upon us; an unprecedented flood now rolls, in unchecked and devastating might, over the land, leaving suffering, death, and destruction widespread in the wake of its resistless currents. I desire here in the name of my afflicted State, to acknowledge with profound gratitude the liberality and generosity of those citizens of other States who have contributed so promptly for the relief of our suffering people. These individual acts of beneficence, together with the aid afforded by Congress in furnishing supplies, will alleviate immediate wants, but the millions of property swept away before the flood can only be replaced by labor and the lapse of time. It is in behalf of the inhabitants of the whole delta, citizens of five great States, that I plead for the aid of the Government. It is for them I invoke the aid of the strong arm of national authority, that the periodical recurrence of these appalling disasters may be averted.

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Owing to the great change in the industrial and domestic relations of the Southern States, though the great body of the newly-made citizens remain upon these lands and are interested in their protection, they can not be controlled and employed in large numbers as they were under the old regime. The great plantations are, in many cases, divided up into small homesteads, and this process is destined to continue. Hence the organized force and capital which once enabled individuals to construct and maintain levees can not hereafter be a reliance.

Since the war there has been no united action by the States whose

alluvial lands are subject to overflow. Louisiana in efforts to reconstruct her own levees has expended more than $8,000,000. Being powerless to make any further efforts, she appeals to you in the name of millions of your own countrymen inhabiting the Mississippi Valley for protection against inundation.

The value of the products of these lands in 1860 exceeded the sum of $150,000,000. With adequate protection from overflow, 55 per cent., the same as the State of Illinois, being under cultivation, would produce a crop exceeding $500,000,000 in value.

Of the extent of this vast expanse of territory, I quote from the able report of your Committee on Mississippi Levees, as follows:

The delta of the Mississippi with its head near Cape Girardeau, in Missouri, sweeps across nine and a half degrees, from 37° 30′ to 29° of north latitude, and contains about 38,706 square miles of area, while the Red River contains in her alluvium about 1,887 miles, and the Arkansas about 500 miles, liable to inundation unless protected by levees. Thus we find the aggregate alluvial area of the Mississippi and connate alluvions dependent upon levees for protection against inundation about 41,193 square miles.

In round numbers the delta requiring protection levees comprises 26,000,000 acres, divided about equally between the cotton and sugar producing districts. The ordinary yield from one-half the cotton acreage would exceed 5,000,000 bales, which at present prices would bring in the market $300,000,000. Would not that amount added to the credit side of our international balance sheet relieve from embarrassment the gentleman from Vermont [Mr. Willard], whose constituents pay their proportion of the interest due foreign bondholders with the proceeds of butter and cheese?

When England discovered that her supply of American cotton would be cut off by the rebellion in this country, she at once began to encourage the cultivation of cotton in India. But the cotton fields of Asia being distant from the seaboards required the construction of railroads at great expense.

This was done without delay, but before a sufficient supply of India cotton reached the mills at Manchester the British Government had expended $450,000,000. Will this Government hesitate in the face of this example to expend $40,000,000 for the protection of an area which is more valuable than the whole of India? But these vast expenditures by England in developing new cotton-fields have resulted in signal failures so far as it was intended to cause a diminution in the demand for American cottons of the best staple.

Prior to 1860 American cotton held supremacy in the markets of the world. Cotton was "king" of American products. Then if king under the baneful hindrances of slave labor, what may it not become under a free and intelligent system of agriculture?

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The gentleman from Vermont (Mr. Willard) does not seem to doubt the power of Congress to improve the Mississippi River as a great highway of commerce between the States. His objection is that the bill looks

to the incidental improvement of the lands which may be reclaimed by keeping the waters of the Mississippi within its bounds. *The distinction is quite too fine for practical minds to grasp.* An enlarged and scientific system of leveeing would certainly greatly benefit navigation by keeping the waters within the channels which nature has marked out. I do not understand the proposition to embrace the old debatable ground of internal improvements of a national character. If it did, certainly the veto messages of Presidents Monroe and Jackson would be in favor of the power to do a work which extends through or bounds six States of the Union and affects the commerce directly of at least one-half and indirectly of the whole Republic. The proposition, if pushed to the extent which the gentleman proposes, would undoubtedly come within the circumscribed limits of the strict constructionist. Nevertheless it received the powerful indorsement of John C. Calhoun in the convention over which he presided at Memphis. In the view of that great man the reclaiming of so vast and necessary a country was a national object in which the Federal Government might engage.

But it is no longer a question of reclaiming lands not cultivated; but it is, Will the nation suffer so vast a belt of cotton and sugar land to be abandoned and given up to the floods? If this were to be done the gentleman from Vermont would find the taxes of New England greatly increased by the diminished crops of cotton and sugar; the diminished tonnage of the Mississippi River; the diminished demand for New England fabrics, and the diminished demand for coastwise shipping. I regret to see that any sectional feeling, not to say prejudice, is invoked upon the subject. The same argument could be employed against every harbor, river, and highway improvement in the Nation. It would have applied emphatically to the railroads which bind the continent together from sea to sea, to all international subsidies, to every law for the protection of domestic industries, and to our laws for mail communication. Certain sections are more immediately benefited than others, but no sections are ever depressed that others may be enriched. And to no section have so few benefits been extended as to the agricultural interests of the South.

Letter from Gen. John H. Rice.

In reply to Professor Haupt, of Pennsylvania, and Prof. J. B. Johnson, of St. Louis.

The Mississippi River problem is the biggest question in the nation to-day, and the river States of the West and Northwest are immensely interested in it. The river is the great and ever-existing agency that controls freight rates on all the trunk-line railroads—East, West, North, and South. Twenty per cent. of the grain shipped to Europe in 1889 went down the river by way of New Orleans. The average freight

rate for this grain was 17⅞ cents per 100 pounds from St. Louis to Liverpool via New Orleans, while on grain shipped from St. Louis by rail to New York and Liverpool the average freight rate was 34 cents, or an actual saving of 16⅛ cents in favor of the river-New Orleans route.

In the Kansas City *Journal* of May 25 are two letters, one from Prof. Lewis M. Haupt, A. M. C. E., of the University of Pennsylvania, and one from Prof. J. B. Johnson, of Washington University, St. Louis. These men are heralded to the reading public as "famous engineers, who have made the river a study." If they have, it is so much greater a misfortune for those universities.

I will notice but one point in Prof. Haupt's letter, namely, that in which he alleges the bottom of the river is rising and that this elevation of bed involves a corresponding raising of levees, with increased cost and greater risk. This is not true, and had Prof. Haupt known anything about alluvial rivers he would not have ventured upon such untenable ground. Bear in mind that this river runs for 1,100 miles over an entirely alluvial bed of its own formation. The beds of such rivers do not rise, only when the water runs unconfined and flows out over its banks at every flood. Scientific investigation made by the ablest and most experienced hydraulic engineers of this country have verified the fact that the "bottom of the Mississippi River has not risen one-fourth of an inch in 100 years"—notably Ellet, Capt. Eads, Humphrey and Abbott, Corthell, Gen. Casey, Chief Engineer United States Army; Gen. Comstock, at the head of the River Commission; Harrod, United States Engineer Kingman, Leach, Suter, Earnst, Fladd, and a dozen others, after a most thorough study, investigations, and measurements, pronounce the "rising-bottom" theory absurd. To bolster this theory, its advocates allege that the bottom of all leveed rivers in Europe, notably the Danube, Po, Rhine, Ganges, Arno, Tiber, and Rhone, have risen. This allegation is not true.

We owe nearly all our knowledge of hydraulics in its various branches, as applicable to rivers, to the celebrated Italian engineers from the twelfth to the eighteenth century—Casina, Torricelli, Guglielmini, Poleni, Manfredi, and others. In 1665 the banking of rivers was proposed by them, and, as a consequence, all the rivers are leveed, and some of them for 400 years, and also the rivers of Germany.

Modern investigation has demonstrated that the bottom of neither the Rhine, Danube, Rhone, Po, Arno, or any leveed river has changed in the height of its bottom one inch in a century.

Gen. Comstock, in his testimony before Senate Committee, May 14, most thoroughly refutes the "rising bottom" theory, and demonstrated that there was nothing in it.

Col. Fladd, of St. Louis, testified before the Commerce Committee of the Senate on May 14 "that he was an engineer for several years on the river Rhine, in Germany; that he knew reliably from data and actual measurements that the bottom of the river was not rising."

Prof. Haupt's theory that levees raise the flood height and the bottom of the river is rising, which increases danger from floods and necessitates from time to time still higher levees, is, in the light of the knowledge of alluvial rivers at this time, an unpardonable error.

A few in this country, claiming to be men of science and to be hydraulic engineers, some of whom never saw an alluvial river and others with no experience on one, are memorializing Congress and filling the newspapers with their theories. We have the Cowdens, the Elseffers, Huntingdon, Haupt, and Johnson theories, all trying to do something they evidently do not understand. The fact that Prof. Johnson was once engineer under the commission is worth nothing in the light of his present utterances. He needs to be taught, instead of teaching others.

The idea of "bottom-rising," which all these anti-levee system men have, is derived from one source—that of M. De Proney—who propagated the error that the bottom of the Po had risen several feet. Lombardini, an eminent Italian engineer, in a memoir on hydraulic conditions of the Po, shows that M. De Proney was absolutely in error. The fact was established by Lombardini that the bed had not risen, but was lower by one foot; and it is now above the level of the adjacent country, although it has been perfectly leveed for 300 years.

Prof. J. B. Johnson, of the St. Louis University, is still more rash in his statements. His errors are:

1. That the flood of 1882 was the highest ever known, before or since.

2. His statement of the amount of water that passed through the swamps of St. Francis Bottoms, Lake Providence and Yazoo swamps and the mouth of Red River.

3. That if this water had all been forced to run in the channel the the flood height would have been raised from 3 to 10 feet, or an average of 8 feet from Cairo to the Gulf.

4. His denial of the claim that the bottom scours out and deepens the channel.

5. His plan to build "weirs" in the present levees.

6. His statement that the levees are torn all to pieces at each flood.

I shall attempt now to show that Prof. Johnson is in error in all these points in his recent letter, and therefore his opinion about this river should have no weight.

1. There were prior to 1882 several floods that surpassed that of 1882. (I will take Natchez as a common point of measurement for all of them.) In 1735, 1770, 1782, and 1796 were great floods, all of them higher than the flood of 1882. [Authority, Martin and the *Evening Journal* of New Orleans.]

In 1811, 1813, 1823, 1824, 1828, and 1836 there were higher floods than in 1882. [Humphrey and Abbott.]

The last flood (1890) was higher than the flood of 1882, namely: At Arkansas City 2 feet, at Greenville 1.7 feet, Lake Providence 2.5 feet, at New Orleans 1 foot above the flood of 1882. Prof. Johnson was simply mistaken.

2. As to the water passing into St. Francis Swamp, Lake Providence Swamp, Atchafalaya, and through crevasses between Red River and New Orleans, Prof. Johnson had no reliable data—simply guessed at it, and guessed very wide of the mark. He states that the amount of water passing Columbus was 1,600,000 cubic feet per second, which was 122,000 feet more than in the flood of 1858, which was as high as

the late flood. The flood water in St. Francis Basin added but little to the volume of water in the river until the actual decline in the river commenced; then it aided to prolong the flood. The mean depths of overflow in this bottom are 2.9, 3 and 5.9 feet, and this water running through woods, with a fall of only about seven inches per mile. With these facts ascertained, it is a terrible stretch of the imagination to say that this bottom discharged, in the late flood, back into the river 200,000 cubic feet per second. The same may be said of the water of Lake Providence Swamp. It goes back into Tensas Basin, down Black River, and the most of it never returns to the Mississippi, but goes down the Atchafalaya.

The flood waters from the Yazoo did not "overtop" the levee on the west side. There were no crevasses there, not one. There was no crevasse on that part of the river front from Raleigh crevasse to Natchez, about 140 miles, and it is amazing that a gentleman of intelligence, professing to write learnedly, and to write facts, should make such egregious blunders. There did pass at New Orleans about 1,400,000 (not 900,000, as Prof. Johnson said) cubic feet per second, and the river was one foot higher than in 1882, notwithstanding that after it reached this stage Nitta crevasse and Bayou Sara and Morganza took place without lowering the flood heights in the channel from Nitta to the head of the passes one-half inch.

3. Prof. Johnson thinks that if all the water had been forced into the channel the flood heights would have been an average of eight feet higher from Cairo to the Gulf. The Professor forgot all about velocity being increased by volume and the amount of water that increased velocity will carry in a channel without increasing the flood height.

The measurements of Humphrey and Abbott show that an increase of 3 feet in the height of the river added 30 per cent. at Carrollton to the discharge, 4 feet added 40 per cent., that an addition of 6.8 feet doubled the discharge of the river, while its velocity was increased 85 per cent. Hence, if a volume of water equal to 6.8 feet could have been added to the river, the discharge per second would have been 2,800,000 feet. This would be 600,000 cubic feet more than Prof. Johnson claims, if all the water had been forced into the channel, and about 1,200,000 more than the accurate amount would have been. It would be very difficult to prove that the flood height would have been raised 1 foot at New Orleans if not one drop of the late flood had escaped from the channel from Cairo down.

A large alluvial river will absorb tributary waters—one river will absorb even another of equal size—without making the flood height either higher or the channel wider. Gennetti and M. Eytelmein supported this fact. Cressy, in the Encyclopedia of Civil Engineering, sustains this opinion, and cites the absorption of the Inn by the Danube, of the Mayne by the Rhine, of the Sechio by the Po, and the Terrene by the Tiber without raising height of surface. The only effect is to increase velocity, and the eminent engineer Guglielmini, in support of the same, cites the fact of the Panaro and Ferrara, branches of the Po, being absorbed by it without any sensible augmentation of its channel. While there is no question of the fact that the Danube, Po, Rhine, and

Tiber in the accessions named have not widened or elevated, the inference is irresistible and it is a fact that they all deepened their channels, and so would the Mississippi. At Cairo the river is a mile wide, then comes in the St. Francis, White, Arkansas, Big Black, Yazoo, and Red Rivers, and at New Orleans it is hardly half a mile wide. Hence it follows that the holding of flood waters in the channel by levees will deepen the channel without elevating the surface of the water, and thus low water navigation will be improved.

4. Prof. Johnson says that the claim that the effect of levees would be to scour out the bottom of the river has no foundation in fact. This is his bold assertion only.

The inclined plane formed by the surface of the river from Cairo to the Gulf is called its slope. The degree of force exerted by the water in its passage depends on the steepness of this slope. The amount of force depends upon the volume of water and upon its velocity, the current being the result of the slope.

The friction of the bed is the chief element that retards the current. The bottom of the Mississippi River is alluvial, which the current is constantly acting upon, and the water is always charged with sediment to the maximum capacity allowed by its velocity. Whenever the channel is only 3,000 feet wide or less we find the water from 60 to 100 feet deep. No exception to this. The water being contracted the volume is increased. This increases the velocity of the water and it picks up the sediment from the bottom and carries it along until this mass of water is dispersed; that is, when the channel spreads out and the water becomes shallower, and immediately the current slows, and at that point the water drops the sediment and it forms a sand bar. When the channel narrows again it picks up other sediment and makes another deep bed, and so on, and if the water was all turned out of the river the bottom would be found to be a succession of deep hollows, from 60 to 150 feet below the banks and hills over 400 feet high across the bed of the river. Now, contract the channel everywhere to a width of about 3,000 feet, and everywhere there would be a deep channel. This water, charged to a maximum, would carry more silt than tributaries brought into it, and in time a bed would be scoured out that would hold all possible flood waters within the banks. But levees are absolutely necessary to hold the flood waters in the channel also, because when there are no levees there are a thousand outlets of every low place, and these retard the current and cause a filling up of the bed of the river. This, the experience of every river man verifies. High water, as Prof. Johnson states, adds to the height of sand-bars, but he takes good care not to state that these sand-bars are always in wide reaches where the water spreads out and becomes shallow and slackens the current, and, being heavily charged at flood time, drops on these sand-bars still more sand.

5. Levees do not increase flood height. I have shown above that the increase of quantity of water when contracted to a normal channel does not elevate surface of water.

Before there was a rod of levee above the mouth of Red River there were twenty floods as high or higher than the flood of 1882 or the late

one, and the water ran over the banks in a thousand low places and inundated the whole country. This was because the bottom of the river filled up and elevated the surface.

6. It is not true that the levees at every high flood (of course, meaning the late flood) were all torn to pieces. They were not all torn to pieces in the late flood.

There were but 23 crevasses, great and small, aggregating openings of only four and a quarter miles. In a stretch of the river where the flood was the very highest in a distance of 140 miles there was no crevasse. Why did they not hold? Simply because the people did not have money enough to build them sufficiently strong or high. They piled up dirt the best they could without reference to engineering principles. There is to-day 1,095 miles of levee intact that resisted the late flood, and the engineers testify that $10,000,000 will build them high and wide enough to hold any possible flood. Oh, but the levees benefit private property; they improve low-water navigation also. All the engineers on the river testify to this. Then why not kill two birds with one stone. Not a dollar is appropriated to build a custom-house or court-house without benefiting private property, still such works are necessary.

Prof. Johnson has a theory. He is down on outlets; he thinks they would be ruinous. He is right. His theory of control is to build "weirs." Well, did he ever see or hear of "weirs" being built on an alluvial river? If so, will he tell us where, when, and how many "weirs" were built, and on what river? How many "weirs" would it take to carry off sufficient water to relieve the river of a flood? An outlet at New Orleans would have to discharge 577,000 cubic feet a second to lower the flood 6 feet 8 inches, and this amount would not affect the height of the flood 40 miles above the outlet. Will Prof. Johnson tell us how many "weirs," 3 feet deep, put in levee, would carry off 577,000 cubic feet per second, and what would he do with the water when he got it out? Then wouldn't he have an elephant on his hands?

Such schemes, even when they do emanate from the pen of "famous engineers," would be laughable for their folly if the subject were not so important a one.

The great West has a vital interest in the control of this river. The commerce of the whole country is interested in it. The value of all the sugar lands, the rice lands, and the value of 30,000 odd square miles of the richest alluvial land God ever created is involved in it. It is a national river, the Government owns it and is bound by every principle of justice and right to take care of its own property so as not to injure the property of the people.

JOHN H. RICE.

JUNE 16, 1890.

OPINIONS OF NATIONAL STATESMEN.

John C. Calhoun, the strictest of strict constructionists, said of it, in 1845, in a speech delivered at Memphis:

The invention of Fulton has, in reality, for all practical purposes, converted the Mississippi with all its tributaries into an inland sea. Regarding it as such I am prepared to place it on the same footing with the Gulf and Atlantic coasts, the Chesapeake and Delaware bays, and the Lakes in reference to the superintendence of the General Government over its navigation. It is manifest that it is far beyond the power of individual or separate States to supervise it.

Vice-President Hendricks, in a speech delivered in 1866, said:

That river is under the control of the Government for almost every purpose. It is a great channel of commerce; it is the nation's river; it does not belong to Louisiana, it does not belong to Mississippi; it is the river of all the States.

General Garfield, while in the House of Representatives, said, in support of the bill creating the Mississippi River Commission:

I believe that one of the grandest of our material and national interests, one that is national in the largest material sense of that word, is the Mississippi River and its navigable tributaries. It is the most gigantic single natural feature of our continent, far transcending the glory of the ancient Nile or of any other river on the earth. The statesmanship of America must grapple the problem of this mighty stream. It is too vast for any State to handle; too much for any authority less than that of the nation itself to manage. And I believe the time will come when the liberal-minded statesmanship of this country will devise a wise and comprehensive system that will harness the powers of this great river to the material interests of America, so that not only all the people who live on its banks and the banks of its confluents, but all the citizens of the Republic, whether dwellers in the central valley or on the slope of either ocean, will recognize the importance of preserving and perfecting this great natural and material bond of national union between the North and South.

In his letter of July 10, 1880, accepting the nomination for the Presidency, General Garfield further said:

The Mississippi River, with its great tributaries, is of such vital importance to so many millions of people that the safety of its navigation requires exceptional consideration. In order to secure to the nation the control of all its waters, President Jefferson negotiated the purchase of a vast territory extending from the Gulf of Mexico to the Pacific Ocean.

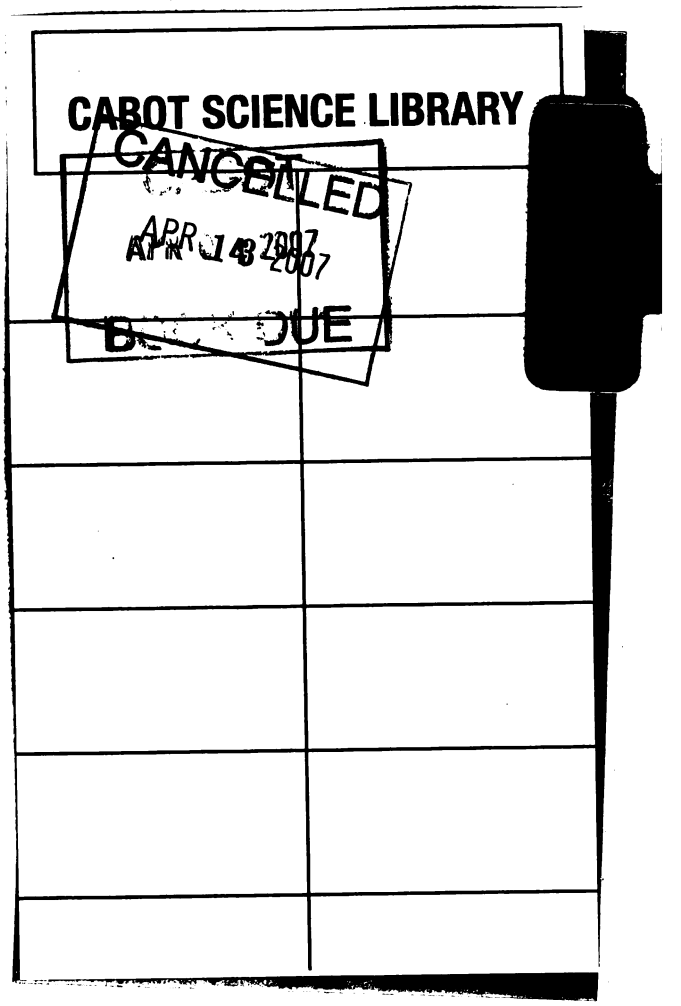
The wisdom of Congress should be invoked to devise some plan by which the great river shall cease to be a terror to those who dwell upon its banks, and by which its shipping may safely carry the industrial products of twenty-five millions of people.

In his annual message to Congress in 1880, President Hayes said:

A comprehensive improvement of the Mississippi and its tributaries is a matter of transcendent importance. These great water-ways comprise a system of inland transportation spread like net-work over a large portion of the United States, and navigable to the extent of many thousands of miles. Producers and consumers alike have a common interest in such unequaled facilities for cheap transportation. Geographically, commercially, and politically, they are the strongest tie between the various sections of the country. These channels of communication and interchange are the property of the nation.

President Cleveland, in a speech delivered at Memphis, Tenn., October 15, 1887, said:

There flows past your city our nation's great river, which you rightly regard as a most important factor in your present and future welfare, and which I believe is universally recognized as a proper object of governmental protection and improvement. To Memphis and to every other city on its banks the improvement of this vast highway of commerce is so essential that they should be interested in having this and other proper work of the same description considered upon their merits, and freed from schemes sometimes questionable in their character and often extravagant in their demands.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